State of North Carolina
Department of Transportation
Highway Design Branch

Structure Design Unit Design Manual

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(1) PURPOSE: The Highway Design Branch - Structure Design Unit Manual has been developed to provide general guidance to Structure Design Unit personnel regarding design policy and operating procedures. The objectives of this manual are to promote efficiency in both design efforts and the transfer of information, as well as to ensure uniformity in contract plan presentation.

(2) MANUAL CONTENT: This manual consists of the following two volumes:

Policy and Procedure Manual: This volume presents the policy and procedure guidelines fundamental to the operation of the Structure Design Unit. This volume contains procedures for the accurate documentation and effective transmittal of information as required for the sequential development of transportation projects.

Design Manual: This volume illustrates standard office practice for the implementation of design criteria and the preparation of transportation structure plans and details.

(3) REFERENCE SYSTEM: A reference system within each volume is maintained such that the chapter number precedes a section number, delineated by a hyphen. The text of each volume is paginated per chapter in the lower exterior corner of the page. Figures, where applicable, are presented at the end of each chapter and are referenced via similar designations.

(4) REVISIONS: This manual is designed as an active document. As new research, products, and procedures evolve, such advances may be periodically incorporated into the body of the manual. To maintain the manual's integrity and continuity, revisions should be immediately appended to the manual as they are distributed.

A master copy of this document, including all revisions, deletions, and additions will be maintained by the Engineering Development Squad of the Structure Design Unit.

PREFACE
DESIGN MANUAL

The Design Manual is one of two volumes of the Highway Design Branch - Structure Design Unit Manual. This manual has been developed for use by Structure Design Unit personnel and other professionals for guidance in the design of transportation structures for the North Carolina Department of Transportation. The primary objective of this volume is to provide standard office practice regarding design, details, and notes, thereby enhancing efficiency in the design effort and uniformity in the presentation of contract plans.

This manual accommodates both English and Metric (Systeme Internationale) units. The English units are considered primary while the Metric units are presented parenthetically throughout the text. The English figures are included at the end of each chapter. The Metric figures are designated identically to the English figures. The English and Metric figures are presented on the opposing faces of the same page. All plan notes contained in the manual are accented with bold text, italicized, and indented from the body of the text.

The Design Manual is intended to be a technical manual, providing Engineers and Technicians guidance in current design practice. This compilation of design practice results primarily from experience in both contract plan development and the construction of highway structures.

To preserve the autonomy of the Engineers and Technicians and encourage the application of new ideas and technology, this manual does not attempt to address all possible scenarios that may arise in the design of highway structures. Indeed, it is assumed that many of these guidelines will necessarily continue to evolve.

The users of this manual are encouraged to present ideas that may vary from those contained herein. These suggestions will be considered and implemented as deemed appropriate.

This manual does not attempt to reproduce information that is adequately addressed in text books, design publications, or the AASHTO LRFD Bridge Design Specifications.

CHAPTER 1
PLAN PREPARATION

1-1 General

The contract plans contain engineering drawings from which the project is to be constructed; therefore, they should contain all information necessary for the contractors to submit sound bids and to construct the project with minimum revisions. The plans should be concise without repetitious notes and details.

The standardization of various items such as line weights, lettering, reference notes, etc., is a significant factor in producing uniformity and clarity in plan presentation. Personnel should become thoroughly familiar with all information presented herein and its application to the plans.

For plan sheet sequence see Figure 1-1.

1-2 Drafting Instructions

Accuracy is an important element in preparing construction plans. The technician should carefully check dimensions of details to ensure that errors are minimized.

The accuracy for dimensions used in the preparation of plans is shown in Figure 1-2. The accuracy for items not listed should be consistent with the figures shown in this manual.

Determine which details should be included and how to present them so that elements which are related are shown together on the sheet and not scattered throughout the plans.

1-3 Plan Sheets

The standard Structure Design Unit plan sheets are 34 inches (864 mm) wide and 22 inches (559 mm) high. The border lines shall be 1 ½ inches (38 mm) from the left edge and ½ inch (12 mm) from the right, top and bottom edges, making an area 32 inches (813 mm) wide by 21 inches (533 mm) high.

To ensure legible prints, when final plan sheets are reduced in size, the minimum size lettering used shall be 1/8 inch (3.2 mm), see Figure 1-3.

Line symbology shall as shown in Figure 1-4. Designate skew angles as shown in Figure 1-5. Figures 1-6, 1-7, 1-8, 1-9 and 1-10 are provided for computing bridge geometry and layout.

CHAPTER 2
DESIGN DATA

2-1 Variations from Current AASHTO LRFD Bridge DesignSpecifications and Interims

Article 3.5 Permanent Loads

For all bridge floors, except those on movable spans, the design dead load shall include an additional 30 lbs/ft^2 (1.4 kN/m^2) for future bituminous wearing surface. For movable spans and other unusual type spans, use 8 lbs/ft^2 (0.4 kN/m^2) for future wearing surface.

Article 3.6 Live Loads

For all highways regardless of truck traffic, the minimum live load, designated as HL-93, shall consist of a combination of the design truck or design tandem coincident with the design lane load. Design for the HL-93 loading that results in maximum force effects. . See Section 2-4. For continuous spans, determine the maximum negative moment between points of contraflexure and the reaction at interior piers by positioning two trucks 50 feet apart as specified in the LRFD Specifications.

Provide adequate clearance to avert design for vehicle collision and rail car collision with structures. Discuss situations where sufficient clearance cannot be provided with the State Bridge Design Engineer. See the paragraph in this chapter for variations to Article 3.6.5.2., as well as Section 7-11 and 7-12 of this manual.

Article 3.6.4 Braking force

Take the braking force, BR, as 5% of the design truck plus lane load or 5% of the design tandem plus lane load.

Article 3.6.5.2 Vehicle and Railcar Collision with Structures

Abutments and piers within distances less than 30 ft. to the edge of roadway shall be protected with a concrete barrier and approach guardrail in lieu of being designed for the equivalent static force of 400 kips. Abutments and Piers within 25’-0 of the centerline of a track must be protected by a crashwall. See Section 7-11 and 7-12.

Article 4.6.2 **Approximate Methods of Analysis**

Design the exterior beams and stringers to have at least as much capacity as interior beams and stringers.

Article 4.6.3 **Refined Methods of Analysis**

When a refined method of analysis is used, a table of live load distribution factors for maximum force effects in each span shall be provided in the plans to aid in future analyses for permit issuance and bridge rating.

Article 9.7.2 **Empirical Design: Concrete Decks**

In general, empirical design of concrete decks shall not be permitted.

Article 10.7.1 **Driven Piles: Spacing, Clearances, and Embedment**

Center-to-center spacing for 12 inch (305 mm) prestressed concrete piles shall not be less than 2'-9" (840 mm) in footings. In general, embed pile heads into concrete as follows:

Embedment - Type of Pile
(Dimension to be measured at centerline of pile)

Type of Structure		Steel HP	Steel Pipe	12" (305 mm) Prestressed Concrete	Prestressed Concrete Larger Than 12" (305 mm)
Abuts. & Ret. Walls		9" (230 mm)	12" (300 mm)	9" (230 mm)	12" (300 mm)
End Bent & Bent Caps		12" (300 mm)	9" (300 mm)	12" (300 mm)	12" (300 mm)
Integral End Bents		24"	24"	24"	24"
Pile Footings		9" (230 mm)	12" (300 mm)	9" (230 mm)	12" (300 mm)

NOTE: Special cases, including Seismic Performance Zone 2 or vessel impact analyses, may require more embedment.

Article 5.7.3.4 **Crack Control by Distribution of Reinforcement**

The maximum spacing requirements of d/6 shall not apply to caps of end bents or multi-column piers.

Article 5.9.4.1 **Allowable Stresses: Temporary Stresses Before Losses Due to Creep and Shrinkage**

Areas other than the precompressed tensile zone

- For girders, box beams, and cored slabs: 0.2 ksi (1.38 MPa) or $0.0948\sqrt{f'_{ci}}$ (ksi) ($0.25\sqrt{f'_{ci}}$) at end.

Article 5.9.4.2 **Allowable Stresses: Stress at Service Limit State After Losses**

Tension in the Precompressed Tensile Zone,

- Box beams and cored slabs at all sites: 0 psi (0 MPa) at mid span
- Girders at corrosive sites: 0 psi (0 MPa)
- Prestressed concrete panels at corrosive sites: 0 psi (0 MPa)

For other girders and panels, the tension is limited to $0.19\sqrt{f'_c}$ (ksi) ($0.45\sqrt{f'_c}$ MPa).

Article 6.6.1.3.1 **Transverse Connection Plates**

For intermediate diaphragms on rolled beams used in simple spans, the vertical connector plate need not be rigidly connected to top and bottom flanges. There shall be a 4 inch (100 mm) gap between both the top and bottom flanges and the vertical stiffener. See Figures 6-103, 6-104 and 6-105 for details.

Article 6.13.2.3 **Bolts, Nuts, and Washers**

All high strength bolts shall have a hardened washer under the element turned in tightening.

Article 14.7 Material Properties

When designing elastomeric bearings, the shear modulus shall be 110 psi (0.76 MPa) for 50 durometer hardness and 160 psi (1.10 MPa) for 60 durometer hardness. Use Method A when designing elastomeric pads and steel reinforced elastomeric bearings.

Article 14.6.3.2 Force Effects Resulting from Restraint of Movement at the Bearing: Moment

The moment transferred by elastomeric bearings need not be considered in the design of bridge substructures or superstructures.

2-2 Culverts and Buried Structures

Design culverts and buried structures in accordance with AASHTO Standard Specifications for Highway Bridges.

Articles 8.15.5.7 and 8.16.6.7 Special Provisions for Slabs of Box Culverts

- Service Load Design - Shear stress v_c shall be computed by AASHTO Equation 8-14, but v_c need not be taken less than $0.95\sqrt{f'_c}$ $(0.08\sqrt{f'_c})$ for single cell or multicell box culverts.
- Load Factor Design - Shear strength V_c shall be computed by AASHTO Equation 8-59, but V_c need not be taken less than $2\sqrt{f'_c}\,bd$ $(0.017\sqrt{f'_c}\,bd)$ for single cell or multicell box culverts.

2-3 Live Loads

Minimum design live load shall be HL-93 (MS18) unless otherwise instructed by the State Bridge Design Engineer.

2-4 Permanent Loads

An additional permanent (dead) load must be included in the design when using metal stay-in-place deck forms. This additional permanentload will consist of 3 lbs/ft^2 (0.145 kN/m^2) for the weight of the metal form plus the weight of concrete in the valleys of the forms which shall be taken as the weight of 1 inch (25 mm) additional concrete over the deck area formed. For wide girder spacings, consideration should be given to increasing this weight due to the possible use of deeper stay-in-place forms.

When prestressed concrete panels are used for prestressed concrete girder spans, girders shall be designed for additional permanentloads due to the possible use of metal stay-in-place forms.

For steel beams and girders, an additional permanentload of 10 lbs/ft^2 (0.48 kN/m^2) shall be included in the non-composite permanent load for the stress check due to the temporary construction loading. When the computer program Merlin-Dash is used for the design, the composite beam should be designed, and the deflections computed without the construction load, see Section 2-6. The non-composite stresses should then be checked with the construction load added and a 1.5 load factor applied for all applicable strength limit states (Load Type 2 in LFD).

Superimposed permanent loads such as barrier rails, medians and any permanent load which would be applied after the deck is cast shall be distributed equally to all beams for bridges up to 44 feet (13.4 m) in width. In the case of bridges over 44 feet (13.4 m) wide, these loads shall be distributed equally to the first three beams adjacent to the loads.

Weights of various types of rails are as follows,

- One bar metal rail: 10 lbs/ft (0.15 kN/m)
- One bar metal rail with 1'-6" (457 mm) concrete parapet: 235 lbs/ft (3.43 kN/m)
- Two bar metal rail with 2'-6" (760 mm) concrete parapet: 455 lbs/ft (6.64 kN/m)
- Three bar metal rail: 25 lbs/ft (0.36 kN/m)
- Concrete barrier rail: 406 lbs/ft (5.92 kN/m) for 2'-8" (813 mm) section
- Concrete median barrier: 414 lbs/ft (6.04 kN/m)

Concrete weight for foundation seal design shall be based on 140 lbs/ft^3 (22.0 kN/m^3).

Unit weights for lightweight concrete are as follows,

- Unreinforced lightweight concrete: 115 lbs/ft^3 (18.0 kN/m^3)
- Reinforced lightweight concrete: 120 lbs/ft^3 (18.8 kN/m^3)

2-5 Non-Composite Permanent Deflections for Steel Bridges

Non-composite permanent (i.e., dead load) deflections for steel bridges shall be computed in accordance with the North Carolina State University research report titled *Development of a Simplified Procedure to Predict Dead Load Deflections of*

Skewed and Non-skewed Steel Plate Girders. This research recommends procedures for modifying non-composite dead load deflections based on a single girder line (SGL) analysis. These procedures are the Simplified procedure (SP), the Alternative Simplified procedure (ASP), and the Single Girder Line Straight Line (SGLSL) procedure. Use the appropriate procedures to modify the SGL predicted non-composite dead load deflections of steel bridges that meet all of the following criteria:

1. Span Length $\leq$ 250 feet
2. Girder Spacing $\leq$ 11.5 feet
3. $\dfrac{\text{Girder Spacing}}{\text{Span}} \leq 0.10$

Non-composite dead load deflections for bridges that do not meet the above criteria will require a more refined analysis that accounts for the stiffness of the entire structure, such as a 3-D finite element analysis.

A more detailed summary of the development and application of the SP, ASP, and SGLSL procedures and an Excel spreadsheet that utilizes these procedures are available via the Differential Deflection link on the Structure Design Unit Homepage.

2-6 Friction Force

The force effects caused by an expansion bearing sliding on its bearing plate on the supporting substructure element must be included in the design of the structure. These forces are determined by multiplying the coefficient of friction by the total permanent load reaction on the bearing. For steel on steel, use a coefficient of 0.30, and for stainless steel on teflon, use a coefficient of 0.10. For elastomeric bearings, the force required to deform the elastomeric pad is found by using the following equation:

$$F = \frac{\text{(Shear Modulus) x (Contact Area) x (Deflection Due to Temperature)}}{\text{Thickness (Effective Rubber)}}$$

2-7 Temperature

Provision shall be made for stresses and movements resulting from variations in temperature.

The range of temperature shall generally be as follows,

- Steel Structures: 0°F to 120°F (-18°C to 50°C)
- Concrete Structures: 20°F to 100°F (-6°C to 38°C)
- Assumed normal fabrication and erection temperature: 60°F (16°C)

For temperature ranges for expansion joints and bearings, see Chapter 6.

2-8 Earth Pressures

Earth pressures on structures such as retaining walls and wing walls which retain fills shall be determined using Rankines' Formula. In special cases good engineering judgment will be required in determining the most suitable design method. In no case shall a structure be designed for less than an equivalent fluid pressure of 40 lbs/ft^3 (6.3 kN/m^3).

2-9 Differential Settlement

When differential settlement needs to be addressed by the Structure Design Unit, the Geotechnical Engineering Unit will indicate the amount of differential settlement in the Foundation Recommendation. If no differential settlement is specified in the recommendation, then the differential settlement has been considered by the Geotechnical Engineering Unit in their foundation design. Generally, the Geotechnical Engineering Unit will consider differential settlement in their foundation design if it is less than 1 inch (25 mm) over a period of time. If the differential settlement is greater than 1 inch (25 mm) over a period of time or if the structure is particularly sensitive to settlement, then the Structure Design Unit must consider the specified settlement in the bent design.

2-10 Dynamic (Seismic) Loads

<u>All structures must be designed in accordance with the seismic requirements of the AASHTO LRFD Bridge Design Specifications</u>.

CHAPTER 3
MATERIALS

3-1 General

All materials and workmanship shall be in accordance with the current NCDOT Standard Specifications and the Special Provisions.

3-2 Structural Concrete

- Class AA Concrete shall be specified for all concrete used in bridge superstructures, bridge substructures at Corrosive Sites, and approach slabs.
- Class A Concrete shall be specified for all other bridge substructures, retaining walls, Reinforced Concrete Box Culverts (RCBC) and miscellaneous structures.
- Drilled Pier Concrete shall be specified for all drilled piers.
- Class B Concrete shall be specified for all slope protection and concrete rip rap.
- Class S Concrete shall be specified for underwater footing seals.

The feasibility of using lightweight concrete shall be investigated for deck rehabilitation projects.

3-3 Reinforcing Steel

Deformed steel bar reinforcement shall conform to the requirements of AASHTO M31 for Grade 60 (AASHTO M31M for Grade 420). The allowable stresses shall be as specified in the AASHTO LRFD Bridge Design Specifications.

3-4 Structural Steel

Structural steel, unless otherwise directed, shall conform to AASHTO M270 Grade 36 (250), 50 (345), 50W (345W), or HPS 70W (HPS 485W).

3-5 Treated Timber

Treated timber is to be given the following treatment and surface finish:

**Retention of Chromated Copper Arsenate (CCA)
and Surface Finish Requirements**

	lbs/ft^3 (kg/m^3) * of Material	Surface Finish
Bulkhead Boards	0.6 (9.6)	S1S1E
Slopeboards, Cornerpieces and Dead Men	0.6 (9.6)	Rough
Crown Strips	0.6 (9.6)	Detail
Joists	0.6 (9.6)	S1E
Joist Cleats	0.6 (9.6)	S2S
Flooring	0.6 (9.6)	S1S1E
Bracing**	0.6 (9.6)	Rough
Nailers	0.6 (9.6)	S1S
Pile Caps**	0.6 (9.6)	S1S
Sheet Piling	0.6 (9.6)	S4S
Wales and Header in Fender System	2.5 (40.0)	S4S
Piles		
Fresh water or land	0.8 (12.8)	Clean-pealed
Salt water	2.5 (40.0)	Clean-pealed

* Material specified above to retain 0.6 lbs/ft^3 (9.6 kg/m^3) of CCA preservative shall retain 2.5 lbs/ft^3 (40.0 kg/m^3) if it is to be utilized in salt water.

** When no other 0.6 lbs/ft^3 (9.6 kg/m^3) treatment is required, treat bent caps and bracings same as piles.

CHAPTER 4
PRELIMINARY DRAWINGS

4-1 Preliminary General Drawings

General The following general guide shall be used in the preparation of Preliminary General Drawings. See Figures 4-1 and 4-2.

Section Along Centerline Survey (Bents on Section at Right Angles to Bents)

- End slopes
- A berm 1'-6" (450 mm) above the bottom of cap for a level berm and a minimum of 1'-6" (450 mm) for a sloped berm
- Elevation of breaks in the ground line to the nearest foot (0.1 m) ±
- Profile grade data
- Span and bent designations (Span A, B, C, End Bent 1, Bent 1, 2, etc.)
- Location of fixed and expansion bearings
- Elevation at top of footings (if known)
- Size and type of piles to be used (if known)
- Begin and end stations and grade point elevations at the fill face of end bents
- Substructure
- Existing Structure – The existing structure should be shown and labeled in the section view. Do not indicate structure removal

The horizontal and vertical scales used for plotting the profile along the centerline survey and the plan view shall be indicated by showing the station and elevations just outside the top and left margins. The horizontal and vertical scales should be the same.

Plan View

- Substructure (with approximate out-to-out dimensions)
- Rip rap outlines
- Slope protection outlines
- Centerline ditch or P.I. of the vertical curve
- North arrow
- Skew angle as shown in Figure 1-5 (also angle of intersection with road or railroad below if angle is different from skew angle)
- Identification Station
  - ◊ For grade separations, the identification station is the intersection of

the centerline survey with the road or railroad, regardless of whether it is on or under the bridge. The intersection station along the -Y- line or ramp should always be shown below the identification station.

◊ For all bridges, show the distance to the nearest bent if the identification station is not at the centerline of a bent.

- Span lengths and the overall length from fill face to fill face of end supports (arc lengths if on horizontal curve)
- Survey Line designations (-L-, -Y-, etc.)
- Destination arrows on road
- Work point of each substructure unit
- Approach slabs with the beginning and ending approach slab stations
- Begin and end stations at the fill face of end bents
- Horizontal curve data as shown on roadway plans
- Existing Structure – The existing structure should be shown and labeled in the plan view. Do not indicate structure removal
- Work bridges and temporary causeways, if required

Long Chord Layout (where applicable) - See Section 5-1.

Location Sketch

- Orient the location sketch consistent with the plan view of the structure.
- Survey Line designations (-L-, -Y-, etc.)
- North arrow
- Existing structures, roads, buildings and drainage pipes shown with dashed lines. Show existing wood lines, stream outlines, and other terrain features. Do not indicate structure removal.
- Proposed structure outline
- Skew angle
- Bench Mark located directly above the location sketch
- Destination arrows on road

Other

- Show the TIP number, county and identification station in the spaces over the title block. For grade separations, show both stations, with the identification station on top.
- Unusual conditions or features
- Typical section of the bridge showing roadway width, beam spacing, barrier rail, sidewalk, bicycle lane, etc. State whether spans are continuous or simple; composite or non-composite; rolled beam; plate

girder or prestressed girder; type steel; etc. Note stay-in-place forms or prestressed concrete panels if used.

- Title Block - briefly describe and locate the bridge

  Example: GENERAL DRAWING FOR BRIDGE OVER CONE CREEK ON SR 1551 BETWEEN SR 1545 AND SR 1553

- Federal Aid Project Number (if applicable) in upper right hand corner of the first sheet only.

Notes

Assumed Live Load = HL-93 or Alternate Loading

This bridge has been designed in accordance with the requirements of the AASHTO LRFD Bridge Design Specifications for Seismic Performance Zone 1 *(Zone 2)****.***

For all metric projects,

All dimensions are in millimeters unless otherwise noted.

All elevations are in meters.

For structures at Corrosive Sites,

This structure contains the necessary corrosion protection required for a Corrosive Site.

Stream Crossings

Section View

- Minimum berm width at 1'-6" (450 mm) above the bottom of the cap
- Station and grade point elevation at the beginning of the front slope of the approach fill at both ends of the bridge
- Elevations to the nearest foot (0.1 m) ± of the stream bed and high water elevation with corresponding year
- Water surface elevation to the nearest foot (0.1 m) and the date of survey
- Estimated normal water surface elevation to the nearest foot (0.1 m), if provided by the Hydraulics Unit
- Any unusual anticipated fluctuation in water level, if provided by the Hydraulics Unit (e.g., an upstream dam that routinely opens and closes its gates)

Plan View

- Width of the berm at both sides of both end bents
- Station at the beginning of the front slope of the approach fill at both ends of the bridge
- Flow direction of stream or ebb and flood in saltwater channel
- Name of river or stream

Hydraulic Data

- Design Discharge
- Frequency of Design Flood
- Design High Water Elevation
- Drainage Area
- Basic Discharge (Q100)
- Basic High Water Elevation

In addition to the above data, show the Overtopping Flood Data for all Federal Aid bridges and for other bridges when data is provided.

Overtopping Flood Data
Overtopping Discharge
Frequency of Overtopping Flood
Overtopping Flood Elevation

In case Overtopping Flood Data is not required, the Hydraulics Unit will provide a note to that effect on the Bridge Survey and Hydraulic Design Report. This note should be placed on the plans.

Railroad Overheads

- Horizontal clearance from the track centerline to the nearest part of the substructure pier which will control horizontal clearance.
- Vertical clearance as the minimum distance from top of rail to the bottom of the beam deflected under live load in the zone specified by the railway.
- Track profile elevations
- Roadway drainage in the railroad right of way.
- Milepost number over the title block
- Distance and direction from the intersection of centerline survey with the existing centerline track to the milepost
- Proposed tracks if work to be performed is part of project. Otherwise, do not show future tracks.

- A section perpendicular to centerline track depicting how the bridge length is determined. Show the horizontal distance from centerline track to the front slope at elevation of top of track. In addition, show the natural ground line; do not show theoretical ditch sections or future tracks.
- For CSX railroad overhead projects, show erosion control details and notes of Figure 4-8.
- When the tops of bent footings adjacent to a railroad track are required by the railroad to be a minimum distance below the top of rail, indicate on the plans the maximum allowable top of footing elevation.

Grade Separations

- Pavement width of the road below
- Shoulder to shoulder distance of the road below
- Minimum horizontal clearance as measured from the edge of pavement to the bent cap face or any other part of the substructure that controls horizontal clearance. In the event barrier rail is used for pier protection, the clearance shall also be shown from the edge of pavement to the face of the barrier rail.
- Vertical clearance as the minimum distance from pavement, or usable shoulder if shoulder controls, to the bottom of the beam deflected under live load. For dual lanes, show the vertical clearance for each lane.
- Distance from edge of pavement to the centerline ditch or the P.I. of the vertical curve

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Widening Projects

When existing and proposed centerlines are not coincident, show both and the distance between them.

4-2 Construction Limits Sketches

General

The construction limits are defined as a combination of lines that clear the extremities of the structure by a minimum of 10 feet (3 m). For bridges, these limits should be established by allowing 10 feet (3 m) outside the wings and 10 feet (3 m) outside each fill face, tip of wing, or approach slab if used. For culverts, these limits should be established by allowing 10 feet (3 m) outside the tips of the wing footings. See Figures 4-3 and 4-4.

Structure details are not important except as they relate to the construction limits. Use 10 feet (3 m) minimum as the main criteria in establishing these limits.

Refer to the Policy and Procedure Manual for format and transmittal procedures for Construction Limits Sketches.

Detailing Instructions

Include the following information:

- Title of sketch: Construction Limits Sketch with brief description of structure under title. (Example: Double 12' x 10' RCBC)
- Identification block in lower right corner showing:
  - TIP Number
  - County & Structure Number
  - Station
  - Date
  - Sketch by
  - Checked by
- Distance left and right of centerline roadway to construction limit line, to the nearest foot (0.1 m)
- Stations along centerline roadway of corners of construction limits, to the nearest foot (0.1 m)
- Skew angle
- North arrow
- Station of intersection of centerline structure and centerline roadway
- Line designations (centerline culvert, centerline bridge, centerline survey, -L-, -Y-, etc.)

Use 8 ½" x 11" (216 mm x 279 mm) paper for Construction Limits Sketches, and maintain a ½" (12 mm) margin on all four sides of the sketch.

4-3 Coast Guard Permit Sketches

General

Coast Guard permit sketches are to be prepared for all proposed structures to be built over navigable waters. These sketches are included in the application with the U.S. Coast Guard and/or the U.S. Army Corps of Engineers for approval of construction of the bridge.

Sketches are to be prepared in accordance with the requirements of the Corps of Engineers “Bridge Permit Application Guide.” It is also recommended to refer to the Unit’s file of previous drawings. Size of drawings shall be 8 ½" x 11" (216 mm x 279 mm).

Each sketch shall have a title block in the lower right hand corner similar to the one in Figures 4-5, 4-6 and 4-7. The title block should include the applicant, the waterway and mile point, the location of project (city, county, state), and the sheet number of the total number in the set submitted. Date shall be shown only after checker’s initials.

Place the project number in the lower left margin of all sheets. All maps shall be oriented with north at the top of the sheet and indicated with a north arrow.

Refer to the Policy and Procedure Manual for transmittal procedures.

A statement shall be shown on each copy of the permit sketch if Federal funds will be used to finance the project.

Location Maps

Include the following information:

- Location of the proposed bridge and a small vicinity map, with the proposed bridge location circled on both maps
- Wildlife and waterfowl refuges, historical and archaeological sites, public parks and recreation areas
- The scale(s) of the drawings indicated by bar graphs
- North arrow
- Direction of stream flow
- Towns in project vicinity
- Navigation clearances above the appropriate datum and the 100 year flood level

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Proposed Structure

Plan View

- Length and width of the bridge (proposed and existing)
- Fendering system, if any, indicating the type of material
- Banks of the waterway
- Structures immediately adjacent to the proposed bridge
- Scale of the drawing indicated by bar graphs
- North arrow
- Horizontal clearance normal to the channel
- Channel axis

Elevation View (looking upstream)

- Navigational opening
- Horizontal clearance normal to the channel
- Vertical clearance above the appropriate datum
- Elevation of the waterway bottom
- Amount of fill required
- Scale of the drawing indicated by bar graph

Miscellaneous

For moveable bridges, the drawings shall show the moveable span(s) in both the open and closed position.

When a temporary crossing bridge is proposed, a drawing indicating the required data should be prepared for this bridge also. Use as few sheets as are necessary to clearly show what is proposed at the location. Only the structural details that are necessary to illustrate the effect of the proposed structure on navigation need be shown.

Show the type and location of all navigation lights on the structure.

CHAPTER 5
GENERAL DRAWINGS

5-1 General Drawings

General The following general guide shall be used in the transformation of the Preliminary General Drawing into the General Drawing. See Figures 5-1, 5-2, 5-3, 5-4 and 5-5.

In addition to the information provided in the Preliminary General Drawing, include the following:

Section Along Centerline Survey (Bents on Section at Right Angles to Bents)

- Elevation of top of footings and drilled piers
- Size and type of piles to be used

Plan View

- Substructure without out-to-out dimensions
- Berm width at both sides of end bents and berm elevations

Foundation Layout Sketch

- Location of piles, footings, or drilled shafts for end bents and interior bents with respect to the control line through the work points
- Dimensions for piles, footings or drilled shafts
- All notes and details necessary for laying out the foundation without reference to other plan sheets

Long Chord Layout

For bridges on horizontal curves, a drawing similar to that of Figure 5-3 should be included in the plans. The drawing should be large enough to clearly show:

- Angle between a radial line and the workline of one bent or the fill face of an end bent
- Centerline survey long chord between the fill face of the end bents
- Intersection angle between the long chord and workline at bents and the fill face of end bents
- Dimensions along the long chord between its points of intersection with the fill face of end bents and workline of bents

- Dimensions along the workline of bents between its intersection with the long chord and centerline survey. Also, show this dimension as measured along the long chord.
- Intersection angle between short chords and the workline of bents or the fill face of end bents.
- If the bents are parallel, show the perpendicular dimensions from the baseline to the workline of bents and the fill face of end bents.
- Work point numbers and stations of each bent and end bent
- Line designations and the radius of curve
- Short chord length at centerline survey for each span.

Location Sketch

If Project Services Unit – Utilities Section indicates there are utility conflicts,

For utility information, see Utility Plans and Special Provisions.

If there are no utility conflicts,

No known utility conflicts.

Other

Include the appropriate bridge number above the title block for all bridge plans. For new alignments or for a bridge that replaces a culvert, place the following over the title block:

Bridge No.__________

For bridge replacement, widening or rehabilitation projects, place one of the following over the title block:

Replaces Bridge No. ___________
Widening of Bridge No. _________
Rehabilitation of Bridge No. ______
Widening and Rehabilitation of Bridge No. _______

Do not include the Typical Section as shown in the Preliminary General Drawing.

Show the Total Bill of Material including all quantities in the structure in the same order as they appear in the pay item list. The quantities shall be broken down by superstructure and each substructure unit.

Certain lump sum pay items require station information in the pay item description. The station in the description must always be the identification station of the proposed bridge. For example, the pay item "Removal of Existing Structure at Station _______" must reference the identification station of the proposed structure and not the station of the structure to be removed.

When removal of the existing structure in the area of proposed construction is required, the existing substructure's outline shall be shown by broken lines in the plan and section views based on the best information available. For the plan note, see Section 5-2 "Removal of Existing Structures".

Stream Crossings

In section view, show the rip rap and stone to be placed around the footings for pier scour protection.

When Rock Embankment is used, indicate on both the section and plan views. See Section 7-9.

All Other Structure Types

For railroad overheads, grade separations, and widening projects maintain the information contained in the Preliminary General Drawing.

5-2 General Drawing Notes

General

Maintain standard notes used in the Preliminary General Drawing and add the following standard notes when applicable:

This bridge has been designed in accordance with the AASHTO LRFD Bridge Design Specifications.

For other design data and general notes, see Sheet SN *(Sheet SNSM)*.

For Falsework and Formwork, see Special Provisions.

For Cast-in-Place Concrete Deck Slab Bridges,

All falsework and forms for the cast-in-place deck slab continuous unit shall remain in place until the entire unit is cast and cured.

For Federal Aid projects,

The Contractor shall provide independent assurance samples of reinforcing steel as follows: For projects requiring up to 400 tons *(360,000 kg)* ***of reinforcing steel, one 30 inch*** *(760 mm)* ***sample of each size bar used, and for projects requiring over 400 tons*** *(360,000 kg)* ***of reinforcing steel, two 30 inch*** *(760 mm)* ***samples of each size bar used. The bars from which the samples are taken must then be spliced with replacement bars of the size and length of the sample plus a minimum lap splice of thirty bar diameters.***

When traffic is to be maintained beneath the proposed structure,

> ***For Maintenance and Protection of Traffic Beneath Proposed Structure, see Special Provisions.***

For all prestressed concrete girder bridges detailed with metal stay-in-place forms and satisfying the conditions outlined in Section 6-2 regarding the use of prestressed concrete deck panels,

> ***Prestressed Concrete Deck Panels may be used in lieu of metal stay-in-place forms in accordance with Article 420-3 of the Standard Specifications.***

For plans detailed with metal stay-in-place forms,

> ***Removable forms may be used in lieu of metal stay-in-place forms in accordance with Article 420-3 of the Standard Specifications.***

For projects with navigable waterways,

> ***For Securing of Vessels, see Special Provisions.***

When top-down construction is required,

> ***This bridge shall be constructed using top-down construction methods. The use of a temporary causeway or work bridge is not permitted.***

For Railroad overpass projects,

The railroad track top of rail elevations shown on the plans are from the best information available. Prior to beginning bridge construction, verify the top of rail elevations and report any variations to the Engineer. Any plan revisions necessary to achieve the required minimum vertical clearance will be provided by the Department.

When bicycle lanes are on bridges,

> ***All pavement marking will be in accordance with the pavement marking plans and shall provide for bicycles.***

When the fills at the bridge approaches are to be placed by the Division of Highways,

> ***Roadway work will be done by the Division of Highways.***

When the wearing surface on widened bridges is to be placed by the Division of Highways,

> ***Wearing surface will be placed by the Division of Highways.***

When Rock Embankment is required,

For Rock Embankment and Core Material in areas of End Bents, see Roadway Plans.

Work on End Bents shall not be started until approach rock embankment and core material in the area of end bent piles have been placed.

For removing existing pavement and scarifying roadbed, see Section 12-3,

The existing pavement within the area of the end bent piles shall be removed and the roadbed scarified to a minimum depth of 2'-0"*(610 mm)***.**

When a causeway is detailed,

At the Contractor's option, and upon removal of the causeway, the Class II rip rap used in the causeway may be placed as rip rap slope protection. See Special Provisions for Construction, Maintenance and Removal of Temporary Access at Station ___________________.

When needle beam supports are not required,

Needle beams will not be allowed unless otherwise called for on the plans or approved by the Engineer. (Prestressed concrete and structural steel superstructures only)

Steel

For weathering steel,

All structural steel shall be AASHTO M270 Grade 50W *(345W)* ***and painted in accordance with System 4 of Article 442-7 of the Standard Specifications unless otherwise noted on the plans.***

For non-weathering steel,

All structural steel shall be AASHTO M270 Grade 50 *(345)* ***and painted in accordance with System 1 of Article 442-7 of the Standard Specifications unless otherwise noted on the plans.***

For projects which include the removal of, or attachment to, an existing structure which has a lead based paint system,

Inasmuch as the paint system on the existing structural steel contains lead, the Contractor's attention is directed to Article 107-1 of the Standard Specifications. Any costs resulting from compliance with applicable state or federal regulations pertaining to handling of materials containing lead based paint shall be included in the bid price for "Removal of Existing Structure at Station ___________________".

Corrosion Protection

Corrosion protection measures shall be highlighted on the General Drawing using the notes below, as dictated by Section 12-13,

> ***The Class AA concrete in the bridge deck shall contain fly ash or ground granulated blast furnace slag at the substitution rate specified in Article 1024-1 and in accordance with Articles 1024-5 and 1024-6 of the Standard Specifications. No payment will be made for this substitution as it is considered incidental to the cost of the Reinforced Concrete Deck Slab.***
>
> ***All metallized surfaces shall receive a seal coating as specified in the Special Provision for Thermal Sprayed Coatings (Metallization).***
>
> ***Class AA concrete shall be used in all cast-in-place columns, bent caps, pile caps, and footings, and shall contain calcium nitrite corrosion inhibitor. For Calcium Nitrite Corrosion Inhibitor, see Special Provisions.***
>
> ***All bar supports used in the*** *(barrier rail, parapet, sidewalk, deck, bent caps, columns, pile caps, footings)* ***and all incidental reinforcing steel shall be epoxy coated in accordance with the Standard Specifications.***
>
> ***The concrete in the*** *(columns, bent caps, pile caps, footings, and/or piles)* ***of Bent No. ______ shall contain silica fume. Silica Fume shall be substituted for 5% of the portland cement by weight. If the option of Article 1024-1 of the Standard Specifications to partially substitute Class F fly ash for portland cement is exercised, then the rate of fly ash substitution shall be reduced to 1.0 lb*** *(1.0 kg)* ***of fly ash per 1.0 lb*** *(1.0 kg)* ***of cement. No payment will be made for this substitution as it is considered incidental to the various pay items.***

Geotechnical

All general foundation, pile, drilled pier, and footing notes will be provided in the Foundation Recommendations. These notes shall be placed on the general drawings. A list of standardized foundation recommendation notes is available on the Structure Design website.

Excavation and Shoring

For excavation at the ends of bridges, show a cross-hatched area extending to the top of the rip rap or slope protection.

For an estimated quantity of unclassified Structure Excavation of 500 yd^3 (380 m^3) or more,

> ***The material shown in the cross-hatched area shall be excavated for a distance of ______ ft*** *(m)* ***each side of centerline roadway as directed by the Engineer. This work will be measured and paid for at the contract unit price per cubic yard (cubic meter) for Unclassified Structure Excavation.***

For an estimated quantity of less than 500 yd^3 (380 m^3),

The material shown in the cross-hatched area shall be excavated for a distance of _______ ft (m) each side of centerline roadway as directed by the Engineer. This work will be paid for at the Contract Lump Sum price for Unclassified Structure Excavation. See Section 412 of the Standard Specifications.

For bridges over highways or railroads in cut sections,

Work shall not be started on this bridge *(or specific parts of bridge)* ***until roadway section has been excavated.***

For foundation excavation on railroad right of way, when applicable, see Section 12-12.

For Temporary Railroad Shoring, See Special Provisions.

The Contractor's attention is called to the fact that the shoring and excavation plans have been submitted to the Railroad by the State. As of the time of plan printing for advertisement for bids, Railroad approval has not been received. When such approval is received, the Contractor will be notified by addendum. In the event Railroad approval is not given prior to submission of bids, the Contractor shall submit bids based on the contract plans. The Contractor shall not begin excavation at the locations shown on these plans until notified of Railroad approval.

When shoring is required adjacent to existing bridges,

Steel sheet piling required for shoring shall be hot rolled.

Temporary shoring will be required in the areas indicated in the Plan View. See Special Provisions for Temporary Shoring. (Pay item included in Structure plans.)

When shoring is required for maintenance of traffic,

For limits of Temporary Shoring for Maintenance of Traffic, see Traffic Control Plans. For pay item for Temporary Shoring for Maintenance of Traffic, see Roadway Plans.

Temporary Structures

When a temporary structure is required,

The Contractor will be required to construct, maintain and afterwards remove a temporary structure at Station ______ for use during construction of the proposed structure. For Construction, Maintenance and Removal of Temporary Structure, See Special Provisions.

When ADTT < 500, also include,

For Sand Seal, see Special Provisions.

When a TL-3 barrier rail is required, place the following note on the plans:

The bridge rails on the temporary structure shall be designed for the AASHTO LRFD Test Level 3 (TL-3) crash test criteria. For Construction, Maintenance and Removal of Temporary Structure, see Special Provisions.

Removal of Existing Structures

(After serving as a temporary structure) ***the existing structure consisting of*** *(number, length and type of spans; clear roadway width and type of floor)* ***on*** *(type of substructure)* ***and located*** *(distance up or downstream from proposed structure)* ***shall be removed. The existing bridge is presently posted below the legal load limit. Should the structural integrity of the bridge further deteriorate, this load limitation may be reduced as found necessary during the life of the project.*** (When a special circumstance exists warranting a Special Provision, add to the note: ***See Special Provision for __________.***)

(After serving as a temporary structure) ***the existing structure consisting of*** *(number, length and type of spans; clear roadway width and type of floor)* ***on*** *(type of substructure)* ***and located*** *(distance up or downstream from proposed structure)* ***shall be removed****.* ***The existing bridge is presently not posted for load limit. Should the structural integrity of the bridge deteriorate during construction of the proposed bridge, a load limit may be posted and may be reduced as found necessary during the life of the project.*** (When a special circumstance exists warranting a Special Provision, add to the note: ***See Special Provision for __________.***)

For removal of an existing structure in the area of proposed construction,

The substructure of the existing bridge indicated on the plans is from the best information available. Since this information is shown for the convenience of the Contractor, the Contractor shall have no claim whatsoever against the Department of Transportation for any delays or additional cost incurred based on differences between the existing bridge substructure shown on the plans and the actual conditions at the project site.

For removal of an existing bridge, or portion thereof, over water,

Removal of the existing bridge shall be performed so as not to allow debris to fall into the water. The Contractor shall remove the bridge and submit plans for demolition in accordance with Article 402-2 of the Standard Specifications.

CHAPTER 6
SUPERSTRUCTURES

6-1 Guidelines for Selecting Type of Superstructure

Bridges shall be designed as continuous or continuous for live load, whenever possible. Regardless of superstructure type, a concerted effort shall be made to minimize the number of joints. All bridges shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications criteria for Seismic Zone 1 or 2. Refer to Figure 2-1 to determine whether a bridge is located in Seismic Zone 1 or 2.

When it is necessary to haul very long or heavy prestressed concrete or steel girders into remote areas, access routes should be checked to make reasonably certain that limited load capacities of existing bridges or sharp curves do not prevent the shipment of these girders to the bridge site. Since it is not feasible to transport AASHTO Type V and VI prestressed concrete girders over land due to weight limitations, these girders should only be used for coastal structures that are accessible to barge traffic. If restrictions exist, place a note on the plans to draw the Contractor's attention to the existing conditions. Section 105-15 of the Standard Specifications addresses restrictions of load limits in the vicinity of the project.

If steel is selected for the superstructure, the use of AASHTO M270 Grade 50W (345W) weathering steel is preferred to painted structural steel when atmospheric corrosion is not a problem. For restrictions on the use of weathering steel, see Section 12-12.

AASHTO M270 Grade 50W shall typically be used for plate girders. However, for continuous structures, a hybrid combination of HPS 70W in the flanges of the higher moment regions and Grade 50W steel in other areas results in the optimum use of HPS and should be considered if girder spacing could be increased in order to eliminate a girder line.

In general, design two span bridges over divided highways and one span bridges in lieu of three span bridges over non-divided highways. Bridge piers are permitted in the median of a divided highway but shoulder piers are not permitted adjacent to the travelway. Early coordination with Roadway Design is necessary to ensure that vertical alignments provide adequate clearance for economical superstructure depths. For estimated superstructure depths, as provided to both the Roadway Design and Hydraulics Units, see Figure 6-1.

Generally, for stream crossings, the use of prestressed concrete girders is preferred. However, since the use of prestressed concrete is often limited by the span lengths and freeboard, consideration should be given at each site for the most feasible span arrangement and type. The use of cored slabs or box beams should only considered where it is not feasible to use a prestressed girder or steel girder bridge. For more than four spans, do not use box beams or cored slabs.

For short span stream crossings, prestressed concrete cored slab or box beam bridges are more economical than continuous cast-in-place deck slab bridges. Only when conditions are contrary to the general design guidelines for cored slabs and box beams should consideration be given to the use of continuous cast-in-place deck slab bridges.

6-2 Decks and Overlays

General

The clear width for new bridges on streets with curb and gutter approaches shall be the same as the curb to curb approach width except where sidewalk or bikeways are carried across the structure. The 2'-0" (610 mm) gutter widths are based on the use of the standard 2'-6" (760 mm) curb and gutter. If other curb and gutter widths are used, bridge widths shall be adjusted accordingly.

Follow the Roadway plans and Structure Recommendations for crown drops for all bridges, superelevated or non-superelevated, except for special cases such as wide roadways and curb and gutter approaches. For superelevated sections with curb and gutter approaches, continue the superelevation to the gutter on both sides. When the roadway crown of dual lanes is sloped from the inside edge of pavement, the bridge crown should also be sloped from this point.

A profilograph test on the final deck surface is required for all bridges greater than 1500 feet (460 m) in length and have a concrete riding surface. Place the following note on the plans:

For Bridge Deck Rideability and Grooving, see Special Provisions.

The riding surface of reinforced concrete bridge floors shall be grooved within 18 inches (460 mm) of the gutter lines and 2 inches (50 mm) of expansion joints. Approach slabs that do not contain an asphalt overlay shall be grooved to the same limits as the bridge floors. The pay item for this work shall be “Grooving Bridge Floors” on a square foot (square meter) basis.

Steel superstructure plans shall be detailed for metal stay-in-place forms. Prestressed concrete girder plans shall be detailed for precast prestressed concrete panels except as noted in this section under “Cast-in-Place Concrete Decks, Precast Prestressed Concrete Panels”. The Contractor may opt to use removable forms for steel span structures and removable forms or metal stay-in-place forms for prestressed girder spans. For the note to be placed on the General Drawing, see Section 5-2 “General”.

For corrosion protection of bridge decks, see Section 12-13.

Cast-in-Place Concrete Decks

Slabs Supported on Beams or Girders

Use the office standard slab design tables as shown in Figures 6-2, 6-3, 6-4 and 6-5 for designing slabs to carry a HL93 live load. Limit the overhang widths from the centerline of girder to edge of superstructure to the applicable suggested maximum overhang shown in Figure 6-6. Figures 6-7 and 6-8 may be used to summarize the slab design and determine the required beam bolster heights.

For a specified beam or girder spacing, the slab design tables provide the total slab thickness, main reinforcement (top and bottom 'A' bars), longitudinal reinforcement (bottom 'B' bars) and the size of beam bolsters upper (BBU). The tables are based on Grade 60 (Grade 420) reinforcing steel and a concrete compressive strength of 3500 psi (24.1 MPa). The top 'A' bars in the slab have been designed for continuity over several supports and have been analyzed for cantilever action in overhangs consistent with Figure 6-6. If plan details are not consistent with these conditions, the designer must check to determine whether the overhang loads control the design of top 'A' bars. There will be some conditions, such as superelevated sections with large horizontal curve offsets, bridges on sag vertical curves, or increased girder camber that will require an increase in the slab thickness or buildup.

Longitudinal steel in the top of slab for prestressed concrete girder superstructures shall be as follows:

- Simple Spans - #4 bars at 1'-6" (#13 bars at 450 mm) centers with metal stay-in-place forms or #4 bars at 9" (#13 bars at 220 mm) centers with prestressed concrete deck panels
- Continuous Spans - See Section 6-3 "Continuous for Live Load Deck Slabs"

In prestressed concrete girder spans, place the following note on plans:

> ***Longitudinal steel may be shifted slightly, as necessary, to avoid interference with stirrups in prestressed concrete girders.***

Longitudinal steel in the top of slab for structural steel superstructures shall be as follows:

- Simple Spans - #4 bars at 1'-6" (#13 bars at 450 mm) centers
- Continuous Spans - Follow the AASHTO LRFD Bridge Design Specifications

The main reinforcement should be set to provide 2 ½ inches (65 mm) clear from top of slab and 1 ¼ inches (32 mm) clear from bottom of slab or the top of the metal stay-in-place forms.

The main reinforcing steel is to be placed perpendicular to the chords for all horizontally curved bridges regardless of the skew.

For skews less than 60º or greater than 120º, detail three #6 (#19) 'A' bars in the top of the slab for the acute corners of deck slabs. These bars shall be placed parallel to the joint, spaced at 6 inches (150 mm), and extended beyond the centerline of the first interior girder.

If beam or girder spacings are closer than usual, thereby resulting in a thin slab and light slab steel, a check shall be made to determine if slab steel is adequate to the resist the load from the railing.

For deck overhangs, detail the bottom of the slab overhang to be approximately parallel to the deck slope, even in superelevated sections. Show the deck overhang at the outside edge of the slab to the nearest ¼" (6mm).

When integral piers or abutments are detailed, the substructure and superstructure are connected such that additional restraints against superstructure rotation are introduced. This results in the potential to develop negative moments due to live loads in the vicinity of the abutment. As such, for a minimum distance of 0.2L, measured from the approach slab blockout, provide a minimum of 1 percent total longitudinal reinforcing steel, with two-thirds of the steel placed in the top mat and one-third in the bottom mat of steel reinforcement. For Integral Abutment bridges, see Section 7-2. Also detail a construction joint, at least 6ft. from the approach slab blockout, such that the deck slab shall be poured prior to pouring the portion of the integral abutment above the bottom of the girders. Figures 6-119, 6-120, 6-121, 6-122 and 6-123 show details at the integral end bent for steel girder and concrete girder superstructures.

Slabs as Main Supporting Members (Cast-in-Place Deck Slab Bridges)

Design these spans in accordance with the AASHTO LRFD Bridge Design Specifications. The main reinforcement should be set to provide 2 ½ inches (65 mm) clear from top of slab and 1 ¼ inches (32 mm) clear from bottom of slab and the beam bolster spacing shall be 1'-6" (450 mm).

Metal Stay-In-Place Forms

Metal stay-in-place forms shall be used for all structural steel spans and prestressed concrete girder spans in non-corrosive sites.

For continuous steel beam or girder spans, place the following note on the plans:

Metal Stay-in-Place Forms shall not be welded to beam or girder flanges in the zones requiring Charpy V-Notch test. See Structural Steel Detail Sheets.

Precast Prestressed Concrete Panels

When precast prestressed concrete panels are used, the Contractor is responsible for the design and details of the panels and the submittal of the plans for approval.

Prestressed concrete deck panels shall be used only on prestressed concrete girders and only within the following limits:

- Skew limits as shown in Figure 6-9. Spacings greater than 8'-6" (2.59 m) should be checked for skew allowance.
- Girder build-ups less than 5" (125 mm).
- Structures with girder lines less than 2 inches (50 mm) out of parallel from bent to bent.
- Maximum superelevation of 0.05.
- When total length of structure exceeds 250 feet (75 m) for stream crossing, check for floating water access. If floating water access in unavailable, do not use prestressed panels.

Do not use prestressed concrete deck panels for:

- Projects requiring staged construction and a positively connected temporary bridge rail,
- Projects with sidewalks requiring deck drains.

If the 4 foot (1.22 m) wide panel skew limit as given in Figure 6-9 is the only limitation exceeded, place the following note on the plans:

The skewed end conditions of Span ___ at Bent No. ___ are such that the use of 4' *(1.22 m)* ***wide prestressed concrete deck panels is not possible; however, the use of 8'*** *(2.44 m)* ***wide prestressed concrete deck panels is possible.***

The general guidelines for plan preparation incorporating prestressed concrete deck panels are as follows:

- The Standard PDP1, "Precast Prestressed Concrete Deck Panels", shall be used. The Contractor has the option of using either a grout bed or a polystyrene support system.

- The longitudinal steel in the cast-in-place portion of the slab shall be #4 bars at 9" (#13 bars at 220 mm) centers with simple span girders. For longitudinal reinforcing in continuous deck slabs, see Section 6-3 “Continuous for Live Load Deck Slabs”.
- The top bars shall be supported above the top of the precast panels by beam bolsters at 3'-0" (1.0 m) centers. See Figure 6-74 .
- In the overhang of the slab, specify #4 bars at 1'-6" (#13 bars at 450 mm) centers for the bottom layer of transverse reinforcement detailed with two bar supports.
- When prestressed concrete panels are used at a Corrosive Site, see Section 12-13.

Steel Grid Floors

Structures shall not be designed with open steel grid floors.

Deck Drains

General

Drains shall not be located over unprotected fill slopes, traffic lanes, or shoulders. If locating drains over slope protection is unavoidable, disallow the use of the stone slope protection option (Alternate “B” on Standard SP1).

PVC pipes, 6 inch (152 mm) nominal diameter, shall not be used adjacent to an unprotected sidewalk. As an alternative, detail a 4 inch (102 mm) nominal diameter PVC pipe at a spacing determined by the Hydraulics Unit, or at a minimum of 6 feet (1.8 m) on center.

For drains to be used with prestressed concrete girder bridges, see Figure 6-12. For drains to be used with rolled beam or plate girder bridges, see Figure 6-13.

In some circumstances, the Hydraulics Unit may require scuppers to be placed on the bridge. Use Standards BS1 and BS2 “Bridge Scupper Details”. When a collection system will not be attached to the structure, see Figures 6-14 and 6-15 for additional details. Detail the location of the inlet on the Typical Section and Plan of Span sheets.

Stream Crossings

Deck drainsrequirements are shown on the Hydraulic Report.

- Prestressed girder and cast-in-place deck slab bridges shall be detailed with 6" (152 mm) ϕ PVC drains pipes extending vertically through the bridge deck and spaced at 12'-0" (3.6 m) centers.

- Cored slab and box beam bridges with an asphalt wearing surface shall be detailed with a flat faced rail to facilitate the widest possible 4" tall (above the wearing surface) drainage opening in the rail. The openings should be as wide as is practical, while maintaining the required concrete cover for the reinforcing bars in the rail. Also, apply

  When necessary, New Jersey barrier rails shall be detailed with 4" (102 mm) ϕ PVC drains spaced at 6'-0" (1.8 m) centers. These drains shall be placed on top of the cored slab units and extended horizontally through the rail with a 4 inch (100 mm) overhang.

- For structural steel bridges, the drains shall be 6" (152 mm) ϕ PVC pipes extending vertically through the bridge deck and spaced at 12'-0" (3.6 m) centers unless the grade is greater than 2% on a normal crown deck 40 feet (12.2 m) or less in clear width. For this situation, work with the Hydraulics Unit to see if the drain spacing can be increased. Where deck drains have a significant impact on bridge aesthetics, the deck drains shall be painted. Place the same note on the plans that is used when deck drains are required on weathering steel grade separations.

Bridges identified by the Hydraulic Report as being in close proximity to particularly sensitive waters shall be designed to eliminate direct discharge from the deck into the receiving water. Contact the Structure Utilities group in the Design Services Unit for assistance in plan preparation for the collection system.

Grade Separations

Drains are generally not required unless the bridge deck has a clear width greater than 40 feet (12.2 m), the superelevation is greater than 0.03, the bridge is longer than 350 feet (105 m), or there are other unusual drainage conditions. If any of these conditions exist, work with the Hydraulics Unit to develop the drainage details.

When deck drains are required on weathering steel grade separations, place the following note on the plans:

> ***PVC deck drains shall be painted with two coats of brown primer meeting the requirements of Article 1080-12 of the Standard Specifications. Each coat shall be 2 dry mils*** *(0.050 mm)* ***thick. Deck drains shall be roughened prior to painting. No separate payment shall be made for painting PVC deck drains as this is considered incidental to the pay item for Reinforced Concrete Deck Slab*** *[Sand Lightweight Concrete]* **.**

The above note shall be modified and placed on the plans when deck drains are required for painted structural steel superstructures.

Railroad Overheads

Drains are not required except in very unusual circumstances. In these instances, approval must be obtained from the railroad for all drainage systems.

Sidewalks and Concrete Median Strips

When a sidewalk is required by the Structure Recommendations, it shall be 5'-0" (1500 mm) or 5'-6" (1650 mm) wide and 6 inches (150 mm) high. See Figures 6-16, 6-17 and 6-18.

Cover for the reinforcing steel shall be 2 ½ inches (65 mm) minimum clear to the top bar and 1¼ inches (32 mm) clear to the bottom 'B' bar. The transverse reinforcing steel shall be #4 bars at 1'-0" (#13 bars at 300 mm) centers in top of the sidewalks. Also detail 4 - #4 (#13) dowels in the transverse direction at 7'-0" (2.1 m) centers in the longitudinal direction. The longitudinal reinforcing steel shall be as detailed in Figures 6-16, 6-17 and 6-18**.** .

Where a permanent median strip is required on the bridge, the reinforcing steel shall be epoxy coated and detailed as shown in Figure 6-19.

Provide the same opening for the expansion joint in the median strip as that in the deck opening. See Figure 6-19 for details.

When a sidewalk or a median strip is shown, place the following note on the plans:

> ***Grooved contraction joints, ½"(12mm) in depth, shall be tooled in all exposed faces of the sidewalk [median strip] in accordance with Article 825-10(B) of the Standard Specifications. The contraction joints shall be located at a spacing of 8ft. to 10ft. (2.4m to 3.5m) between expansion joints. No contraction joints will be required for segments less than 10 feet (3.5m) in length.***

Bridge Rails

Railing, sidewalks and guardrail anchorage shall conform to the current AASHTO LRFD Bridge Design Specifications. All bridge railing systems must be successfully crash tested in accordance with NCHRP Report 350 or be identified as crash equivalent at a test level of TL-3 or higher. Railings below a test level of TL3 may be used on non-NHS routes with design speeds less than or equal to 45 mph or in conjunction with a sidewalk, in accordance with the Bridge Policy.

Concrete Rails

Bridges with no sidewalks and with reinforced concrete decks shall typically have a concrete barrier rail as detailed in Figures 6-20, 6-21, 6-22, 6-23 and 6-24.

Standard CBR1- “Concrete Barrier Rail” should be used in the plan development of reinforced concrete decks. Standard CBR1 is drawn to show general details. Modification may be needed to match a particular structure. The plan view of the end of rail detail and the plan of spans showing reinforcing steel in barrier rail shall be shown on the Standard CBR1. When unarmored evazote joint seals are used in the deck joint, #5 (#16) ‘S3’ and ‘S4’ bars shall be installed using an adhesive bonding system near the joint as shown in Figure 6-25. When an armored evazote joint with elastomeric concrete is used, do not adhesively anchor these bars. Use ‘S1’ and ‘S2’ bars, or comparable, in lieu of the ‘S3’ and ‘S4’ bars. For an example of the use of Standard CBR1, see Figure 6-26.

Use ½ inch (13 mm) expansion joint material at 30 foot (9 m) maximum centers when using any type of concrete barrier rail or concrete median barrier rail. Provide an expansion joint in the rail over all continuous bents. All reinforcing steel in concrete barrier and median barrier rails shall be epoxy coated. For median barrier rail details, see Figures 6-27, 6-28, 6-29, 6-30 and 6-31.

For permanent concrete median barrier rails, the width and height will be as required by the roadway typical section at the bridge. When using New Jersey type median barrier, extend the barrier a minimum of 3 inches (75 mm) beyond the approach slab and square off the end.

Barrier rail details for cored slab structures are shown on the Standard PCS3 “Prestressed Cored Slab Unit”. The plan view showing the reinforcing steel in the end of the barrier rail should be shown on the Standard PCS3. The reinforcing steel and stirrups for the barrier rail shall be shown on the Plan of Spans.

Metal Rails

Eight Structure Standard drawings are available and should be used for plan development:

- BMR1 - “1 Bar Metal Rail”
- BMR2 - “Rail Post Spacings and End of Rail Details for One or Two Bar Metal Rails”
- BMR3 - “2 Bar Metal Rail”
- BMR4 - “2 Bar Metal Rail”
- BMR5 - “3 Bar Metal Rail”
- BMR6 - “3 Bar Metal Rail”
- BMR7 - “3 Bar Metal Rail”
- BMR8 - “Guardrail Anchorage Details for Metal Rails”

Metal rails shall be as shown on the Standards. The post spacing shall be a maximum of 6'-6" (1980 mm) on center.

For Standard Metal Rails, provide the same movement capability in the rail’s expansion joint as that in the deck opening. Show the rail opening on the appropriate Metal Rail Standard. Provide an expansion joint in the rail over all continuous bents.

Three Bar Metal Rails are used for structures with sidewalks. Use Standards BMR5, BMR6, BMR7, and BMR8. The post closest to the end post shall be placed as shown on Standard BMR5. The next two posts shall be spaced at a distance of one-half the normal post spacing not to exceed 3'-3" (990 mm). Post spacing and end post details should be drawn on an additional plan sheet. Guardrail attachments should be shown on Standard BMR8. See Figure 6-32.

Two Bar Metal Rails are used for structures carrying bicycle routes. Use Standards BMR2, BMR3, BMR4, and BMR8. The post closest to the end post shall be placed as shown on Standard BMR3. Post spacing should be drawn on Standard BMR2 and guardrail attachments should be shown on Standard BMR8. Also include the end post and parapet details shown in Figures 6-33 and 6-35 on an additional plan sheet. Figure 6-36 details barrier rail steel for One and Two Bar Metal Rails on cored slabs. Figure 6-37 details barrier rail steel for One and Two Bar Metal Rails on box beams.

Other types of rail are to be used in special cases only. If One Bar Metal Rail is used, use Standards BMR1, BMR2 and BMR8. The post closest to the end post shall be placed as shown on Standard BMR1. The next two posts shall be spaced at a distance of one-half the normal post spacing not to exceed 3'-3" (990 mm). Post spacing should be drawn on Standard BMR2 and guardrail attachments should be drawn on Standard BMR8. Also include the end post and parapet details shown in Figures 6-34 and 6-35 on an additional plan sheet.

The pay item for parapets for one and two bar metal rails shall be “1'-___ x ___" Concrete Parapet” (“___ x ___ mm Concrete Parapet”) and paid for per linear foot (meter).

Temporary Bridge Rail

For staged construction the Traffic Control, Pavement Marking, and Delineation Section of the Traffic Congestion and Engineering Operations Unit (Traffic Control) may require a temporary bridge rail. The pay item for temporary bridge rail will be a Traffic Control item and a Roadway detail or standard. Close coordination between Structure Design, Roadway Design and Traffic Control is extremely important. The following procedure shall be followed:

The Project Engineer shall contact the Roadway Project Engineer and the Traffic Control Section Head to determine the width of the bridge deck needed to maintain traffic during construction. This will determine the location of the temporary barrier. The offset distance shall then be the distance from the back of the barrier to the edge of the slab.

If the offset distance is less than 6'-0" (1830 mm), the portable concrete barrier [Roadway Standard 1170.01] shall be anchored to the slab. The same anchorage is required when a temporary barrier divides opposing traffic and is 2'-0" (600 mm) or less from the edge of any traffic lane. Traffic Control will be responsible for determining pay limits and estimating pay item quantities. The Project Engineer should include a sketch of the barrier including the offset distance and the following note should be added to the plans:

See Traffic Control Plans for location and pay limits of the anchored portable concrete barrier.

The Project Engineer shall furnish the beginning and ending approach slab stations to the Traffic Control Section Head and the Roadway Design Engineer.

If the offset distance is 6'-0" (1830 mm) or greater, the portable concrete barrier [Roadway Standard 1170.01] shall be used but attachment to the bridge deck is not required.

Project Engineers shall submit the Preliminary General Drawing in addition to the requirements of the above paragraphs to the Traffic Control Section as soon as they are developed.

Guardrail Anchorage

General

Guardrail transition and attachment details shall satisfy the requirements of NCHRP Report 350. Roadway Design will recommend the location of guardrail attachments to the bridge on the Structure Recommendations or the Roadway plans. Guardrail Anchor Unit Type III, used to attach a thrie-beam guardrail to a vertical face parapet, will typically be specified for bridges using metal rails and flat faced parapets. Guardrail Anchor Unit (GRAU) Type B-77 rail [Roadway Standard Drawing 862.03], is typically used for bridges with a jersey barrier. Typically, guardrail anchorage is required at all four corners of the bridge, though the trailing ends of dual structures may not require guardrail in the median if certain conditions are met.

Concrete Barrier Rails

In some cases, concrete barrier rail transitions are required in order to provide a vertical face for the guardrail attachment. This transition section and the guardrail attachment will occur on the approach slab. See Section 12-1 "Barrier Rail Transitions".

For most cases, guardrail will attach directly to the New Jersey barrier rail on the bridge using thru bolts and a B-77 GRAU. Standard GRA2 is available and should be used for plan development.

Metal Rails

The end posts for each metal rail are located on the bridge and have a vertical face to which the guardrail will attach. A sketch showing points of guardrail anchor assembly attachments should be drawn on the Standard BMR8. See Figures 6-32, 6-33, and 6-34 for location of the guardrail anchor assembly.

Construction Joints

General

All continuous or continuous for live load bridges shall contain at least one transverse construction joint, regardless of pour quantities.

For continuous steel bridges, regardless of pour quantities, indicate the required pour sequence and location of joints. Determine a pour sequence that will minimize the residual dead load tensile stress in the deck. In general, the Wisconsin DOT Pouring Sequence, as shown in Figures 6-38 and 6-39, should be used to determine the joint locations as measured along the survey line.

For continuous for live load prestressed girder bridges, regardless of pour quantities, detail construction joints approximately 5 feet (1.5 m) to 10 feet

(3.0 m) from the edge of the bent diaphragms, as shown in Figure 6-40. A range is provided to allow for optimization of the pour quantities. . Also, detail the optional pouring sequenceas shown in Figure 6-41. When detailing the optional pouring sequence, provide a transverse construction joint within an individual pour sequence only if the pour quantity for that segment exceeds the limits shown below.

Additional joints shall be provided, if necessary, to limit the above pour quantities as follows:

- For prestressed concrete girders with precast deck panels, detail a permitted transverse construction joint for pours between 100 and 200 yd^3 (76 and 153 m^3) and a construction joint for pours over 200 yd^3 (153 m^3).
- For all other superstructure types, detail a permitted construction joint in the deck for pours between 250 and 300 yd^3 (190 and 230 m^3) and a construction joint for pours greater than 300 yd^3 (230 m^3).

Transverse construction joints shall be placed along the skew. See Figure 6-42 for details. For all skewed bridges, extend full-length transverse reinforcing steel through transverse construction joints.

Longitudinal reinforcing steel should extend a minimum of a development length beyond all transverse joints.

In cast-in-place deck slab bridges where the slab is to be cast monolithically with the bent caps, detail a permitted construction joint between the bottom of the slab and the top of the bent cap. In addition, detail a permitted transverse construction joint in the slab along the centerline of each bent within the continuous unit. Longitudinal reinforcing steel must be extended through these joints as required by design. Transverse reinforcing steel shall not be extended through the skewed transverse construction joints.

Longitudinal Joints

Longitudinal joints are necessary for staged construction. To facilitate form placement and removal and to eliminate the possibility of water leaking through the joint onto the flanges, longitudinal joints for staged construction shall be located 1 foot (300 mm) from the centerline of the beam or girder. For AASHTO Types V and VI and Modified Bulb Tee prestressed concrete girders, this joint shall be located 2 feet (600 mm) from the centerline of the girder.

AASHTO Types V and VI, and Modified Bulb Tee prestressed concrete girders shall typically be spaced at 6 feet (1830 mm) surrounding the longitudinal joint. All other beams or girders shall typically be spaced at 4 feet (1220 mm) surrounding the longitudinal joint.

Transverse reinforcing steel should not extend through longitudinal joints. Use dowels here in the top of the slab only. The dowels are placed through the formwork prior to casting the concrete for the deck. Place the following note on the plans:

Dowels shall be placed in the same horizontal plane as the top slab reinforcing steel.

Closure Pours

For prestressed concrete superstructures with staged construction, detail a closure pour the entire bridge length if any span exceeds 100 feet (30.5 m) in length. Always detail a closure pour for structural steel superstructures with staged construction, regardless of the span length. Locate the longitudinal joints and space beams or girders according to the requirements of "Longitudinal Joints" above.

Expansion Joints

General

The type of expansion joint or seal to be used at a deck joint is generally determined by the length of expansion for which the joint is provided and the skew angle of the joint.

The maximum and minimum design temperatures for expansion joints shall be 10° to 110°F (-12° to 43°C) for steel beams with a concrete slab and 20° to 105°F (-7° to 41°C) for concrete beams with a concrete slab. The total movement shall be computed as follows:

$$\text{Total Movement, } M_{TOT} = \alpha L(T_{MAXDESIGN} - T_{MINDESIGN} + 30°F(17°C))$$

•

Where L is the expansion length and α is the coefficient of thermal expansion.

Provide #5 (#16) 'G' bars parallel to the joint and extending the full width of the bridge. The 'G' bar shall be located as close to the joint edge as possible. Care should be taken to ensure that the 'G' bar can be tied to other reinforcing steel. Place the following note on the plans:

#5 (#16) G__ bar may be shifted slightly, as necessary, to clear reinforcing steel and stirrups.

When a prestressed girder extends across a skewed joint and under the adjacent span, $^3/_8$ inch (10 mm) expansion joint material shall be placed on the portion of the top flange extending under the adjacent span. See Figure 6-75.

Evazote Joint Seals

For a maximum joint opening of 3 ½ inches (89 mm) normal to the centerline of the joint at 20°F (-7°C) for concrete superstructures or at 10°F (-12°C) for steel superstructures, use an evazote joint seal at both interior bents and end bents.

The joint shall be sawed prior to the casting of the barrier rail or sidewalk. Figures 6-43 and 6-44 are to be used as a guideline for selecting the joint.

For joints located at interior bents, see Figure 6-45 for typical details to show on the plans.

For joints located at end bents, the joint seal details are provided on the BAS standard drawings. For cover plate details at sidewalks, see Figures 6-46, 6-47 and 6-48.

For projects with a design year ADTT of 2500 or more and all bridges on the NHS, regardless of ADTT, the evazote joint seal shall be armored from gutterline to gutterline. Elastomeric concrete shall be used surrounding the armor and shall also be detailed from gutterline to gutterline. In the sidewalk or barrier rail, a formed opening shall be detailed, in lieu of a sawed joint, with the seal turned up into the sidewalk or barrier rail. Use Standard AEJ1 and modify CBR1 and the BAS standard drawings, as applicable, to show the formed opening and delete all references to the sawed opening.

Payment for the evazote joint seals shall be at the lump sum price for "Evazote Joint Seals". Place the following note on the plans:

> ***The nominal uncompressed seal width of the evazote joint seal shall be _____ at Bent No ___. For Evazote Joint Seals, see Special Provisions.***

Expansion Joint Seals

Where evazote joint seals cannot be utilized, use the standard expansion joint seal. For total movements exceeding 2 ½ inches (65 mm), use the modular expansion joint seal. Maintain a 1 inch (25 mm) minimum joint opening normal to the centerline of joint when fully expanded.

- **Standard Expansion Joint Seals**

  Four Structure Standard drawings are available and should be used for plan development:

  ◊ EJS1 - "Expansion Joint Seal Details"
  ◊ EJS2 - "Expansion Joint Seal Details for Barrier Rail"
  ◊ EJS3 - "Expansion Joint Seal Details for Sidewalk"
  ◊ EJS4 - "Expansion Joint Seal Details for Sidewalk"

  In general, EJS1 and EJS2 are used for barrier rails and EJS1, EJS3 and EJS4 are used for sidewalks. Figures 6-49, 6-50 and 6-51 show examples on the use of the standard drawings for a structure with a sidewalk.

On Standard EJS1, delete the "Expansion Joint Details" that do not apply. The 'J1' bar in the "Expansion Joint Details" should be detailed and included in the Superstructure Bill of Material. See Figure 6-52 for a detail of the 'J1' bar. The 'J1' bar shall be epoxy coated. Compute the total movement and show on the "Movement and Setting at Joint" table on Standard EJS1. See Figure 6-52 for example computations for the "Movement and Setting at Joint" table.

Standard EJS2 illustrates general details. The "Plan of Expansion Joint Seal", left and right sides, shall be detailed on the standard drawing. See Figure 6-53 for details. Show the pavement marking alignment sketch on the plans. This information can be obtained from the Traffic Control Engineer in accordance with the Policy and Procedure Manual. See Figure 6-56 for an example of the pavement marking alignment sketch.

Cover plates will be required over expansion joint seals. Care should be taken in orientation of the cover plates with respect to traffic. The bolts on the cover plate shall be on the side of the approaching traffic. The Type I cover plate has bolts on the left end of the plate when looking at the top of the plate, and the Type II cover plate has the bolts on the right end. In general, Type II will be used for two-way traffic, and Types I and II will be used for structures with one-way traffic. Calculate the length of the cover plate and place this dimension on the standard drawings. See Figures 6-53 6-54, 6-55 and Figures 6-27, 6-28, 6-29 and 6-30 for details on calculating the cover plate length for barrier rails and median barrier rails respectively.

The "Plan of Expansion Joint Seal", left and right sides, should be drawn on Standard EJS3. See Figure 6-54 for the detail showing the "Plan of Expansion Joint Seal" for sidewalks.

Place the pavement marking alignment sketch and the plan view of the sidewalk cover plate on Standard EJS4. See Figure 6-55 for details of the sidewalk cover plate.

Payment for the expansion joint seals shall be at the lump sum price for "Expansion Joint Seals". Place the following note on the plans:

For Expansion Joint Seals, see Special Provisions.

- **Modular Expansion Joint Seals**

For modular expansion joint seals use Structure Standards MEJS1 or MEJS2 for plan development. Do not detail the joint. The contractor will submit detailed drawings and specifications for the proposed modular expansion joint seal. Compute the total movement as described above and show on the standard drawing. Also show cover plate details, the pavement marking alignment sketch and the "Plan of Modular Expansion Joint Seal", left and right sides. See Figures 6-57, 6-58, 6-59 and 6-60 for these and other details to be included in the plans.

For modular expansion joints, no separate quantity is to be shown on the plans for the closure pours adjacent to the joint. Provide header elevations at the transverse construction joints.

For modular expansion joints located at end bents, the backwall and the approach slab details shall be modified as shown in Figure 6-57.

Special snowplow protection of modular expansion joint seals will be necessary on bridges meeting the following criteria:

◊ the bridge is located in Divisions 7, 9, 11, 12, 13 or 14, Wake County, Durham County, Cabarrus County, or Mecklenburg County
◊ the skew angle is between 50° and 70° or between 110° and 130°

When both of the above conditions exist, place the following note on plans:

Special snowplow protection is required. See Special Provision for Modular Expansion Joint Seals.

Otherwise, use the following plan note:

For Modular Expansion Joint Seals, see Special Provisions.

Payment for the modular expansion joint seals shall be at the lump sum price for "Modular Expansion Joint Seals".

Bridge Overlays

For box beam and cored slab bridges, detail either an asphalt or a lightly reinforced concrete overlay. The type of overlay shall be based on the bridge location and the traffic conditions.

In general, the concrete overlay is preferred for its durability and shall be specified on bridges that satisfy any of the following criteria:

- Bridges on NHS routes
- Bridges with design year ADT greater than 5,000
- Bridges with design year TTST greater than 100
- Low water bridges located in Divisions 11-14

Box beam and cored slab bridges that do not meet the above criteria may be detailed with an asphalt overlay.

Concrete overlays shall be reinforced with #3 (#10) bars spaced at 6" (150mm) centers in both the longitudinal and transverse directions. This reinforcing steel mat shall be placed such that the 2"(50mm) clear cover is maintained throughout the overlay surface. Reinforcement in the transverse direction may be placed along the skew. Include full plan details to show the overlay reinforcing steel with a complete bill of material, and the required beam bolsters (BB) at mid-span and centerline bearing. If different height beam bolsters are required to maintain the clear cover, then show the required BB heights at or near the gutter line and at the location that requires the tallest BB. The maximum beam bolster spacing shall be 2'-0" (600mm).

Where concrete overlay is detailed, transverse post-tension the box-beam or cored slab units with 0.6" strands, and place the following note on the plans:

> ***Placement of the concrete wearing surface shall occur after casting the concrete rail. The cost of the #3 (#10) bars cast with the concrete wearing surface shall be included in the unit price bid for concrete wearing surface. For Concrete Wearing Surface, see Special Provisions.***

Since the concrete overlay is only lightly reinforced, avoid detailing relatively deep sections of the concrete overlay. If the roadway plans show a normal crown on a bridge that will have a concrete overlay, then request the Roadway Unit to investigate whether it is possible to revise that section of roadway to a constant superelevation to minimize the overlay thickness.

Consider eliminating joints in concrete overlays. For bridges where adjacent spans, supported on the same bent, are each detailed for a fixed condition, the concrete overlay shall be continuous over the joint. In addition:

- Detail additional 20'-0" long #4 (#13) longitudinal reinforcing steel bars spaced at 6" (150mm) centers, centered over the joint, and placed between existing longitudinal bars,
- Detail a continuous backer rod (joint material) at or near the bottom of the superstructure units, and
- Detail grout to fill the gap between the superstructure units of adjacent spans. This grout should be the same as that used to fill the anchor bolt holes.

For a fixed condition at the end bent, detail an evazote joint between the superstructure unit and the approach slab. .

When through-the-rail drainage is required or an asphalt overlay is shown, detail a flat-faced rail with drainage slots through the rail parapet whenever possible. The use of these rails must comply with the guidelines outlined under the section on Bridge Rails.

Use Design Manual Figure 6-61 to select the overlay type.

Construction Elevations

Construction elevations shall be computed during the plan preparation stage. Three copies for each bridge shall be turned in with the project. One copy shall be retained for the office file and two copies shall be forwarded to the Construction Unit.

A computer program is available for computing these elevations. The output from this program shall be sent to the field along with illustrative sketches of the output.

See the Policy and Procedure Manual for additional information on the Construction Elevations file.

Construction Elevations for Bridge Decks

Furnish construction elevations for all bridges except cored slabs and box beams for the purpose of setting deck forms and screeds and include the following information:

- Crown elevations along the centerline of roadway and overhang elevations at the bottom of the slab along the outside edges of superstructure. These elevations are to be furnished at 4 foot (1.2 m) spacing with an elevation point located on the midspan of each of the three lines specified. At longitudinal construction joints, provide the overhang elevations on the top of the slab at 4 foot (1.2 m) intervals.
- Header elevations along the centerline of each joint at the end bents and interior bents. All header elevations should be provided at 2 foot (0.6 m) intervals normal to the centerline of roadway.

If a longitudinal screed is required, header elevations shall also be provided at all transverse construction joints.

See Figure 6-62 for an example of the sketches required for a skewed span. These sketches shall show the beginning, midpoint and ending stations of Span A for lines 1 and 3 and the identification stations at bents for line 2 as printed on the computer output sheet.

The appropriate sketch for Span A only shall be completed and attached to each of the three copies of construction elevations that are run for each bridge. The sketch of Figure 6-63 is detailed for a tangent bridge but may be used for a curved bridge by designating the degree of left or right curve on the centerline. Figure 6-63 provides blank spaces to be filled in with the appropriate stations. Space is also available in the figure to show a small cross-section of the bridge roadway.

Bottom of Slab Elevations

Bottom of slab elevations shall be furnished for all beams and girders for the purpose of setting the forms for the buildups. These elevations shall be provided at 10th points between the centerline of bearings for each line of prestressed girders, rolled beams, and plate girders with spans less than 100 feet (30.5 m). For plate girders with any span longer than 100 feet (30.5 m), provide bottom of slab elevations at 20th points. If any plate girder span exceeds 200 feet (61 m), provide bottom of slab elevations at 30th points. Separate vertical curve and superelevation ordinates are not needed by the Construction Unit and should not be included in the construction elevations package.

The appropriate sketch is to be completed and attached to each of the three copies of construction elevations. See Figures 6-64 and 6-65.

Construction Elevations for Approach Slabs

Construction elevations are to be computed for left edge, centerline, and right edge of the approach slabs. Use the same criteria for approach slab construction elevations as for bridge deck construction elevations, except all elevations shall be computed for the top of the approach slab.

Utility Supports on Bridges

All details and notes concerning utilities that are to be placed on the plans will be furnished by the Project Services Unit.

See the Policy and Procedure Manual for additional guidance.

6-3 Prestressed Concrete Girders

Design

Girders shall be AASHTO Type II, Type III, Type IV, Type V, Type VI, 63" (1600 mm) Modified Bulb Tee or 72" (1829 mm) Modified Bulb Tee as shown in Figures 6-66 and 6-67. Design for the pretensioning method of prestressing with straight or straight and draped strands as required.

Prestressed girder spans are to be designed for live and dead loads to be carried by the composite action of the slab and girders.

For continuous for live load deck slabs, use the same depth girders at continuous bent diaphragms.

Frequently, girders of the same size and similar length in the same bridge or within bridges of the same project require only slightly different number of strands. In this situation, consideration should be given to using the same number of strands for these girders.

Concrete strengths up to 10,000 psi (68.9 MPa) may be used routinely. Specify high strength concrete (> 6000 psi (41.4 MPa)) only in those spans where required by design. For use of concrete strengths greater than 10,000 psi (68.9 Mpa), consult with the Engineering Development Squad for approval.

The release strength of the concrete shall be no higher than required by design.

High strength seven-wire, low-relaxation (LR) strands shall be used for prestressing. The properties and applied prestressing for the strands shall be as listed below:

Type	Grade	Area	Ultimate Strength	Applied Prestressing
0.50" ϕ LR (12.70 mm)	270	0.153 in^2 (98.71 mm)	41,300 lbs /strand (183.7 kN /strand)	30,980 lbs /strand (137.8 kN /strand)
0.60" ϕ LR (15.24 mm)	270	0.217 in^2 (140.00 mm)	58,600 lbs /strand (260.7 kN /strand)	43,950 lbs /strand (195.5 kN /strand)

All prestressed girder types may be designed with 0.50” (12.70 mm) ϕ straight, debonded, or draped strand patterns. If a straight strand design can be achieved by adding up to 6 strands to the total number of strands required for a draped design, then detail the straight strand pattern on the plans. If the straight strand design requires the addition of more than 6 strands, detail the draped strand design. Draped strand hold down points shall be located 5’-0” (1.500 m) on each side of the centerline of the prestressed girder. However, since steeply draped strands exert a considerable load on hold-down bolts in the bottom of the girder form, the slope on draped strands shall not exceed 12.5%. When the uplift force due to draped strands exceeds 20 kips (89 kN), place the following note on the plans:

The uplift force due to draped strands is ______ kips** (KN)**.

AASHTO Type V and VI girders, and 63" (1600 mm) and 72" (1829 mm) Modified Bulb Tee girders designed using a 0.5" (12.70 mm) ϕ draped strand pattern shall also be designed and detailed with an optional 0.6" (15.24 mm) ϕ debonded straight strand pattern. The shear shall be investigated and detailed separately for both type strand patterns.

When designing debonded strand patterns, the following criteria shall apply:

- The number of debonded strands shall preferably not exceed 25% but never more than 30% of the total number of strands.

- The number of debonded strands in any row shall not exceed 40% of the total number of strands in that row.
- The exterior strands in each horizontal row shall be fully bonded.
- Debonded strands and corresponding debond lengths shall be symmetrically distributed about the centerline of the member.
- Debonded strands in a given row shall be separated by at least one fully bonded strand.
- The number of debonded strands terminated at a given section shall not exceed four.
- The minimum debond length shall be four feet and subsequent lengths shall vary in two feet increments.

When extending a girder type with 0.5" (12.70 mm) ϕ draped strands to its full capacity, a 0.6" (15.24 mm) ϕ debonded straight strand pattern may not be adequate for the same capacity. In this case, design the girder with 0.6" (15.24 mm) ϕ draped strands in order to reduce the total number of strands.

The pattern for the release of the prestressing strands shall not be shown on the plans.

For all girder types with a straight strand pattern, detail at least one pair of strands between the neutral axis and 6 inches (150 mm) from the bottom of the girder to facilitate the tying of stirrups.

Strands at the ends of all Modified Bulb Tees with draped strands shall be debonded in accordance with the criteria described in Article 1078-13 of the Standard Specifications. The debonded strand pattern shall be detailed on the plans. Place the following note on all MBT girder plans:

> ***The Contractor has the option to provide, at no additional cost to the department, 2 additional strands at the top of the girder to facilitate tying of the reinforcing steel. These strands shall be pulled to a load of 4500 lbs. (20 Kn).***

Bevel the ends of the girders only when the grade, skew, or horizontal curve of the structure creates interference at end bents and joint locations. The ends of girders should not be beveled at the bents in continuous for live load spans. The tolerance on girder lengths should be considered when determining the necessity for bevel. Girder length tolerances are provided in the Standard Specifications. Use the sloped bearing-bearing length of girders when the sloped distance exceeds the horizontal distance by more than 3/4 inch (19 mm).

Maintain a minimum of 3" (75mm) clearance between the end of the girder and the end bent backwall.

Notches in the top flange at the end of the Type II and Type III girders are detailed in Standards PCG1 and PCG2. These notches will accommodate most skew conditions. For a 90° skew, eliminate the notch. Modify the 'S3' and 'S4' bars on the Type II girder standard drawing and the 'S3' and 'S6' bars on the Type III girder standard drawing to 'S2' bars. Add two horizontal 'U' shaped 'S3' stirrups in the top flange. For details of these modifications, see Figures 6-68 and 6-69.

Notches in the top flange at the end of the Type IV girder should be detailed on each structure as dictated by skew conditions. Modify the 'S2' bars to straight bars in pairs in the region of the notch. Move the 'S3' bars to clear the notch.

Include a girder layout sheet in the plans. See Figure 6-70 for example.

For the use of prestressed concrete girders at Corrosive Sites, see Section 12-12.

Continuous for Live Load Deck Slabs

In lieu of a more rational design procedure, prestressed girders with continuous deck slabs may be designed for simple span dead plus live loads.

For continuous for live load deck slabs with precast deck panels, detail the top mat of reinforcement as shown in Figure 6-71.

For continuous for live load deck slabs with metal stay-in-place forms, provide slab reinforcement to satisfy composite dead plus live load moments. Comparable to the AASHTO LRFD Bridge Design Specifications for continuous steel girders, provide at least 1% of the cross sectional area of the concrete slab for the longitudinal reinforcement. Two-thirds of this required reinforcement shall be placed in the top layer of slab reinforcement and the remaining one-third shall be placed in the bottom layer. See Figure 6-72 for details.

Stirrups

Stirrup requirements shall be as prescribed in the AASHTO LRFD Bridge Design Specifications. Stirrups are to extend 6 inches (150 mm) above the top of the girder. Consideration shall be given to adjusting this extension when an increased buildup is required.

Slab Thickness

The slab thickness for composite design is to be the thickness of the slab less ¼ inch (6 mm) monolithic wearing surface. The slab shall be constructed with a buildup over the girders between the bottom of the slab and the top of the girder. Provide a minimum 2 ½ inch (65 mm) buildup at the centerline of bearing to accommodate the support system for the panels and 1 inch (25 mm) of final camber in the girder. See Figure 6-73. When metal stay-in-place forms are used, the minimum buildup at the centerline of the bearing may be reduced to 2 inches (50 mm). Regardless of the forming system used, when the final camber of the girder exceeds 1 inch (25 mm), the buildup shall be increased accordingly.

Whenever possible, use a constant buildup at the centerline of all bearings of a bridge to avoid steps in the bottom of the slab across bents.

The dimension at the centerline of bearing may be decreased for spans with crest vertical curves but should be increased for spans with sag vertical curves, large cambers, or superelevated spans on sharp horizontal curves.

The buildup over the girders shall be neglected in the composite design.

Diaphragms

Bent and End Bent Diaphragms

Bent diaphragms for simple span girders shall be cast-in-place concrete with a uniform depth of 1'-6" (460 mm) or 2'-0" (610 mm) below the bottom of the slab as shown in Figure 6-74. See Figures 6-74 and 6-75 for typical details of diaphragms at the interior bents. Show the #8 (#25) 'K' bars going over the girder. For a 90º skew, the 10 inch (260 mm) diaphragms shall be located at the end of the girder.

When the face of the bent diaphragm is offset from the end of the girder, provide additional reinforcement in the concrete between the diaphragm and the centerline of the joint as follows, see Figure 6-74:

- For an offset distance of 5 inches (130 mm) to less than 7 inches (180 mm), use one 'K' bar and #4 (#13) 'S' bars spaced at 12 inches (300 mm).
- For an offset distance of 7 inches (180 mm) to less than 11 inches (280 mm), use two 'K' bars and #4 (#13) 'S' bars spaced at 12 inches (300 mm).
- For an offset distance greater than 11 inches (280 mm), use three 'K' bars equally spaced and #4 (#13) 'S' bars spaced at 12 inches (300 mm).

Bent diaphragms for simple span girders with a continuous for live load deck slab shall be detailed as shown in Figures 6-76 and 6-77. The #4 (#13) 'U' and 'S' bars shall be spaced at 12 inch (300 mm) centers along the diaphragm.

For integral abutment bridges, do not detail the 10" edge beam at the abutment.

Intermediate Diaphragms

The number of diaphragms required per span shall be as follows:

- None for spans less than 40 feet,

- One diaphragm at mid-span for spans between 40 and 100 feet, inclusive,
- Two diaphragms at third points for spans over 100 feet.

<u>For AASHTO Shapes:</u>
Detail intermediate steel diaphragms on all prestressed girder bridges using AASHTO Shapes II, III or IV.

A standard drawing, PCG12 (PCG12SM), is available for use. PCG12(SM) should be used in conjunction with Standard Drawings PCG1, (PCG1SM), PCG2(PCG2SM), PCG3 (PCG3SM), PCG4 (PCG4SM), PCG5 (PCG5SM) and PCG6 (PCG6SM) and may be used for all skew angles. For skews between 70° and 110°, the diaphragm(s) shall be placed along the skew with bent connector plates, as shown on the standard drawing. For all other skew angles, detail the diaphragms normal to the girder web and stagger the connector plates.

<u>For Modified Bulb Tees:</u>
Intermediate diaphragms shall be cast-in-place concrete with 1 ¼" (31.75 mm) ϕ tie rods tightened before casting the concrete. See Figures 6-78 and 6-79. The length of the tie rods shall not exceed 40 feet (12 m). Diaphragms may be staggered in order to keep the length of the tie rod below 40 feet (12 m). Diaphragms shall be placed at right angles to the centerline of the roadway.

Place the following notes on the plans:

> ***Temporary struts shall be placed between prestressed girders adjacent to the diaphragms and the nuts on the 1 ¼"** (31.75 mm) **ϕ tie rods shall be fully tightened before diaphragms are cast. Struts shall remain in place 3 days after concrete is placed. The tie rods shall be re-tightened after the struts have been removed.***
>
> ***Concrete in bent and intermediate diaphragms may be Class A in lieu of Class AA. Payment shall be made under the unit contract price for Reinforced Concrete Deck Slab.*** (Simple spans)
>
> ***Concrete in intermediate diaphragms may be Class A in lieu of Class AA. Payment shall be made under the unit contract price for Reinforced Concrete Deck Slab.*** (Continuous for live load spans)

For prestressed concrete girder superstructures with a closure pour, do not detail intermediate diaphragms in the staging bay.

When the bridge is located at a Corrosive Site, use a grouted recess for the tie rod ends on the exterior girder. See Figure 6-80.

When utilities are attached to a bridge and are in conflict with an intermediate diaphragm, raise the bottom of the conflicting diaphragm to the bottom of the web. If the diaphragm is still in conflict, then eliminate the diaphragm in that bay only.

Camber and Dead Load Deflection

Camber and dead load deflections at 10th points shall be shown for both interior and exterior girders on all prestressed concrete girder spans in the following manner:

Camber (girder alone in place) = ________________↑
Deflection due to Superimposed D.L.* = ________________↓
Final camber (or deflection) = ________________↑ or ↓

* Includes future wearing surface in superimposed dead load.

Deflections and cambers shall be shown in feet (meters) to three decimal places, except the Final Camber which shall be shown to the nearest sixteenth of an inch (millimeter).

The camber and deflection at the time of erection is calculated based on “A Rational Method for Estimating Camber and Deflection in Precast Prestressed Members” as published in the PCI Journal, Volume 22, No. 1. This method applies multipliers to the initial camber and deflection to arrive at the camber at the time of erection. For this method, an average erection time of 28 days after casting is assumed and 73% of the camber is achieved by erection time. The unit weight of the concrete for the camber and deflection computations is assumed to be 142 lbs/ft^3 (22.3 kN/m^3).

6-4 Prestressed Concrete Cored Slabs

Design

Cored slabs are to be of the AASHTO standard shape, Type SIII or Type SIV as shown in Figure 6-81 and are to be designed for the pre-tensioning method of prestressing with straight strands.

Specify high strength concrete only in spans where required by design. The prestressing strands shall be seven-wire, high strength Grade 270, 0.50" (12.70 mm) or 0.6” (15.24mm) ϕ low-relaxation strands.

Generally, cored slabs may be used for skews between 60° and 120° where the grade is 4% or less. Cored slabs are permitted on vertical curves as long as a 2'-8" (813 mm) minimum dimension from the top of the barrier rail to the top of the wearing surface is maintained.

For those projects requiring top-down construction, design the cored slab units for an HS25 for an LFD Design (MS 22.4) or HL93 live load for a LRFD design and limit the bearing-to-bearing span lengths to 50 feet (15.2 m). For note to be placed on the General Drawing, see Section 5-2.

In most cases, the use of cored slabs should be limited to tangent alignments. However, on slight curves, it may be economical to design a cored slab structure detailed with curved pavement markings. If this option is used, the Project Engineer shall coordinate with the Roadway Design Unit as described below.

If the design is known to be a cored slab bridge with barrier rails at the time of the Structure Recommendations, the Roadway Project Engineer should recommend a clear roadway width that is in an even 3'-0" (914 mm) increment. Otherwise, the Structure Project Engineer shall increase the recommended clear roadway width to the next even 3'-0" (914 mm) increment and inform the Roadway Project Engineer of the necessary adjustment. See the Policy and Procedure Manual for an example form letter.

The barrier rail shall be placed such that there is no offset from the edge of the exterior unit to the exterior face of the barrier rail. The barrier rail shall be attached to the exterior units by casting reinforcing steel into the exterior units and pouring the barrier rail after the units are post-tensioned.

When required, a minimum sidewalk width of 5'-0" (1500 mm) or 5'-6" (1650 mm) shall be used unless otherwise recommended. Place the sidewalk and parapet so the offset from the edge of the exterior unit to the exterior face of the parapet is 1 inch (25 mm). See Figure 6-17. If the overall width is not in an even 3'-0" (914 mm) increment, increase the sidewalk width as necessary and inform the Roadway Project Engineer of any adjustments so the guardrail location, where necessary, can be adjusted accordingly.

Three standard drawings are available and should be used in plan development:

- PCS1 - "3'-0" x 1'-6" Prestressed Concrete Cored Slab Unit"
- PCS2 - "3'-0" x 1'-9" Prestressed Concrete Cored Slab Unit"
- PCS3 - "3'-0" x 1'-__" Prestressed Concrete Cored Slab Unit"

Standard PCS1 or PCS2 shall be used in combination with Standard PCS3.

The standard drawings provide general details; therefore, some modification or adjustment may be needed to suit a particular structure. The barrier rail details are drawn for a 2 inch (50 mm) asphalt wearing surface measured at the centerline of the bearing at the gutterline. To accommodate large cambers, this wearing surface thickness may exceed 2 inches (50 mm). In this case, the reinforcing details for the barrier rail should be modified accordingly. See Figures 6-82, 6-83 and 6-84 for an example use of the standard drawings.

Where debonded strands are required, indicate the strands to be debonded on the standard drawing as illustrated in Figure 6-82. Place the following note on the plans:

> ***Bond shall be broken on these strands for a distance of ______ feet*** *(meters)* ***from end of cored slab unit. See Standard Specifications Article 1078-7.***

The offset dimension for the 'S3' bar is based on 1 inch (25 mm) minimum clear distance to the voids. Detail the spacing for the 'S3' bars and the 'U' shaped stirrups to coincide in exterior cored slab units. For cored slab structures with skews less than 75° or greater than 105°, provide additional skewed stirrups between the 'S1' and the first 'S2' stirrup such that the spacing between stirrups does not exceed 1'-0" (300 mm). See Figure 6-85.

For the use of cored slabs at a Corrosive Site, see Section 12-12.

In some cases, the Division office may request that a cored slab project with an off-site detour be prepared as a lump sum project. For instructions on preparing plans for this type of project, see Structure Design Policy memo of April 28, 2004 and September 1, 2004.

Diaphragms

Diaphragms shall be located at the center of spans up to 40 feet (12 m). For spans over 40 feet (12 m), the diaphragms shall be located at third points. If the bridge is on a skew between 60° and 120°, skew the diaphragms also. Through the center of the diaphragm, a 2" (50 mm) ϕ hole shall be formed for the post-tensioned strand. The strand shall be 0.50" (12.70 mm) ϕ seven wire, high strength low-relaxation. The anchorage recess for the strand shall be grouted. See Figures 6-86 and 6-87.

Overlays

Asphalt Overlays:
Detail a "fixed" condition on both ends of all spans. See Figure 6-82.

Concrete Overlays:
For bridges up to 150 ft. in length, detail a "fixed" condition on both ends of all spans.

Where adjacent spans are supported on the same bent and are each detailed for a fixed condition, detail a backer rod near the bottom of the cored slab units and detail grout to fill the gap between cored slab units of adjacent spans. This grout should be the same as that used to fill the anchor bolt-holes.

Camber and Dead Load Deflections

The camber and dead load deflection shall be shown for all cored slab spans in the following manner:

Camber (Girder alone in place) = ________________↑
Deflection due to Superimposed D.L.* = ________________↓
Final camber (or deflection) = ________________↑ or ↓

* Includes future wearing surface, except when a concrete overlay is used.

All deflections and cambers shall be shown to the nearest sixteenth of an inch (millimeter).

The camber and deflection at the time of erection is calculated based on "A Rational Method for Estimating Camber and Deflection in Precast Prestressed Members" as published in the PCI Journal, Volume 22, No. 1. This method applies multipliers to the initial camber and deflection to arrive at the camber at the time of erection. For this method, an average erection time of 28 days after casting is assumed and 65% of the camber is achieved by erection time.

Prestressed Concrete Box Beams Box beams shall be detailed to the dimensions and section properties shown in Figure 6-88, and are to be designed for prestressing with straight strands. For approximate span length limits see Design Manual Figure 11-3. Specify high strength concrete only in spans where required by design. Box beams shall be constructed in a side-by-side layout, similar to the current practice with cored slab bridges.

Design

Box beams may be used for skews between 60° and 120°, and on grades up to 4%. Box beams may be set on caps with a slope of 2% or less. When box beams are used on vertical curves, the 2'-8" (813mm) minimum dimension from the top of the wearing surface to the top of the barrier rail must be maintained. Box beams shall not be used for bridges that require staged construction.
For those projects requiring top-down construction or for projects with span arrangements that permit top-down construction, design the box beam units for top-down construction loads. For box beam bridges where none of the span lengths exceed 55'-0" (16.76m) the top-down construction loads may be approximated with an HS-25 or HL93 loading. However, for bridges where any of the spans exceed 55'-0" (16.76m), design all box beam units for the anticipated construction loads, such as operating and travelling crane loads.

When the Structure Recommendations specify a box beam bridge, the Roadway Project Engineer should recommend an overall (out-to-out) structure width that is an even 3'-0" (914mm) increment. When the Structure recommendations do not show the overall width to an even 3'increment but it is determined that box beams are the preferred structure type, the Structure Project Engineer shall increase the recommended out-to-out dimension to the next even 3'-0" (914mm) increment and inform the Roadway project Engineer of the necessary adjustment. See the form letters available via the Structure Design web page.

The camber and dead load deflection shall be shown for all box beam spans in the following manner:

Camber (Girder alone in place) =_________________ ↑

Deflection due to Superimposed D.L.* =__________ ↓

Final camber (or deflection) =_________________ ↑ or ↓

* Includes future wearing surface, except when a concrete overlay is used.

Cambers and dead load deflections shall be shown for the girder alone in place, and for deflections due to wearing surface. Do not include deflections due to the rail or the future wearing surface in the deflection due to concrete overlay.

All deflections and cambers shall be shown to the nearest sixteenth of an inch (mm). The camber and deflection at the time of erection is calculated based on “A Rational Method for Estimating Camber and Deflection in Precast Prestressed Members” as published in the PCI Journal, Volume 22, No. 1. This method applies multipliers to the initial camber and deflection to arrive at the camber at the time of erection. For this method, an average erection time of 28 days after casting is assumed and 65% of the camber is achieved by erection time.

For concrete overlays, show the dimensions for the minimum overlay thickness at mid-span and the overlay thickness at centerline bearing on the Typical Section. Indicate that the overlay thickness at centerline bearing is based on the predicted deflection due to concrete overlay.

The use of level, unreinforced pads is preferred. The pads shall be designed in accordance with the AASHTO Standard or LRFD Specifications. In general, use 6" (150 mm) by 5/8 inch (16mm) pads as a minimum and provide 1¼ " (32 mm) ϕ holes in fixed end bearing pads and 2½"(64 mm) ϕ holes in expansion end bearing pads for #8 (#25) dowels. Dowels shall be 2'-3" (685 mm) long set 1'-0" (300 mm) into the concrete cap. Do not apply epoxy protective coating to the bent caps of prestressed concrete box beam structures.

Detailing

The expansion joints shall be evazote joints with elastomeric concrete. Detail a full depth (2¼" x 5½") blockout.

The barrier rail shall be placed such that there is a 1" offset from the edge of the exterior unit to the exterior face of the barrier rail. The barrier rail shall be attached to the exterior units by casting reinforcing steel into the exterior units and pouring the barrier rail after the units are post-tensioned, but prior to placement of the concrete overlay.

When through-the-rail drainage is required or an asphalt overlay is shown, detail a flat-faced rail with drainage slots through the rail parapet whenever possible. The use of these rails is limited to off-system bridges.

When required, a minimum sidewalk width of 5'-0" (1500mm) or 5'-6" (1650mm) shall be used unless otherwise recommended. Place the sidewalk and parapet so the offset from the edge of the exterior unit to the exterior face of the parapet is 1" (25mm). See Figure 6-18.

If the overall width is not in an even 3'-0" increment, increase the sidewalk width as necessary and inform the Roadway Project Engineer of any adjustment so the guardrail location, where necessary, can be adjusted accordingly.

Eight standard drawings are available and should be used in plan development.

- PCBB1 – 3'-0" x _'-_" Prestressed Concrete Box Beam Unit
- PCBB2 – 3'-0" x 2'-3" Prestressed Concrete Box Beam Unit
- PCBB3 – 3'-0" x 2'-3" Prestressed Concrete Box Beam Unit
- PCBB4 – 3'-0" x 2'-9" Prestressed Concrete Box Beam Unit
- PCBB5 – 3'-0" x 2'-9" Prestressed Concrete Box Beam Unit
- PCBB6 – 3'-0" x 3'-3" Prestressed Concrete Box Beam Unit
- PCBB7 – 3'-0" x 3'-3" Prestressed Concrete Box Beam Unit
- PCBB8 – 3'-0" x _'-_" Prestressed Concrete Box Beam Unit

Standards PCBB1 and PCBB8 shall be used in combination with Standards PCBB2-7.

Overlays

Asphalt Overlays:
For bridges up to 150 feet in length, detail a "fixed" condition on both ends of all spans.

Concrete Overlays:
Detailing fixed conditions on box beams with concrete overlays should be evaluated on a case by case basis. Details for the joints should mitigate the potential for cracking in the overlay as a result of girder deflection and/or thermal movement.

Where adjacent spans are supported on the same bent and are each detailed for a fixed condition, detail a backer rod near the bottom of the cored slab units and detail grout to fill the gap between cored slab units of adjacent spans. This grout should be the same as that used to fill the anchor bolt-holes.

The standard drawings provide general details. Some modifications or adjustments will be required to suit a particular structure. The barrier rails are detailed for a 3½" (90mm) concrete wearing surface measured at the gutter line at mid-span. The barrier rail reinforcing details should be modified where the concrete wearing surface exceeds the depth shown on the standard details. For use of a one or two bar metal rail, see Figure 6-37. The overlay shall be placed after the barrier rails have been constructed and have cured. Longitudinal joints in the overlay shall not be permitted, except where required for staged construction. Place the following note on the plans:

> ***"Placement of the concrete overlay shall occur after casting the concrete rail [parapet]. For Concrete Wearing Surface see Special Provisions."***

Detail the transverse joints on box beam bridges with evazote joints that incorporate the standard elastomeric concrete filled blockout. In addition, detail a backwall at the end bents.

Where debonded strands are required, indicate the strands to be debonded on Standard Drawings PCBB2, PCBB4, or PCBB6. Place the following note on the Standard Drawing:

> ***"Bond shall be broken on strands as shown for the specified length from each end of the box beam. See Standard Specifications Article 1078-7."***

For the use of box beams at a corrosive site, see Section 12-13.

<u>Diaphragms</u> Diaphragms shall be detailed along the skew and shall be located 8 feet from the ends in addition to the following locations:

- At mid-span of spans up to 60 feet (18.29 m),
- At third points of span lengths between 60 feet (18.29 m) and 85 feet (25.91 m), and
- At quarter points of span lengths over 85 feet (25.91 m).

See Figure 6-89. A pair of 2" (50 mm) ϕ holes, for the post-tensioning strands, shall be formed through the diaphragm and shall be located symmetrically about the mid-height of the box beam section. The post-tensioning strand shall be seven wire, high strength Grade 270, 0.6" (15.24 mm) ϕ, low-relaxation strands. The anchorage recess for the post-tensioning assembly shall be grouted as shown on the Standard Drawings.

6-6 Steel Plate Girders and Rolled Beams

Design

For all steel beam and girder spans, both simple and continuous, use the Load and Resistance Factor Design (LRFD) Method.

When atmospheric corrosion is not a problem, the use of AASHTO M270 Grade 50W (345W) or HPS 70W (HPS 485W) steel is more economical and preferred. When it is necessary to use painted structural steel, AASHTO M270 Grade 50 (345) or Grade 70 (485) should be specified.

Use the fewest number of beams or girders consistent with a reasonable deck design. Use buildups over all beams and girders. When metal stay-in-place forms are used, the buildups shall be the same width as the beam or girder top flange. If metal stay-in-place forms are not used, the buildups shall be detailed approximately 6 inches (150 mm) wider than the beam flange. Indicate on the plans that a chamfer is not required on the corners of these buildups. Buildups should not be provided on the outside of exterior girders. Detail the bottom of slab overhang to be approximately parallel to the deck slope. Show the depth of overhang at the outside edge of the slab to the nearest ¼" (6mm). See Figure 6-90.

For grade separations, use a constant depth for all exterior steel beams or girders. Interior beams or girders shall be designed for the most economical depths, but in no case shall they exceed the depth of the exterior beams or girders. Where the use of short end spans with shoulder piers is unavoidable, tapered plate girders for both interior and exterior girders shall be used in lieu of haunched rolled beams.

Typically, design all beams and girders for composite action. The slab thickness for composite design shall be the slab thickness less ¼ inch (6 mm) monolithic wearing surface.

In the negative moment region of continuous spans, use a consistent number of studs per row as that used in the positive moment region and space the studs at 2'-0" (600 mm). This spacing may be modified at locations of high stress in the tension flange as per the AASHTO Standard Specifications.

For economical and fatigue reasons, do not design rolled beams with cover plates except to match existing beams for rehabilitation and widening projects.

The minimum W-section used as a primary member shall be a W 27x84 (W 690x125). The overhang widths for these rolled beams shall not exceed 27 in (690 mm). When a W27 (W690) steel section is required, place the following note on the plans:

> ***Needle beam type supports are required for the overhang falsework in the spans with 27"*** *(690 mm)* ***beams.***

The end of beams and girders at expansion joints skewed at 90° should be 1 ½ inches (40 mm) from the formed opening of the joint. The end of beams and girders for skewed bridges should be located further from the edge of the expansion joints so that the top flange, which would otherwise project into the joint, can be clipped ½ inch (13 mm) from the formed opening of the joint. See Figure 6-91.

The minimum clear distance between the end bent backwall and the end of the girder is 3” (75 mm).

When designing economical welded plate girders, observe the following rules:

- Maintain a constant web depth and vary the areas of the flange plates. Flange widths in field sections shall be kept uniform where practical. It is far more economical to design a field section with a uniform flange width and a varying flange thickness than vice versa. When a constant flange width is used in a given field section, the fabricator can order wide plates of varying thickness and make transverse butt splices. The fabricator can then cut the pre-welded pieces longitudinally to the specified constant flange width.
- Limit the flange thickness change ratio to 2:1. For example, if using a 2 inch (50 mm) flange plate, do not transition to less than a 1 inch (25 mm) flange plate. For flange and web butt joint welding details, see Figure 6-92.
- When practical, limit the flange plate thickness to between ¾ in (20 mm) and 3 inches (70 mm).
- Limit the number of welded flange geometry transitions. Approximately 600 lbs (270 kg) of flange material must be saved to justify the introduction of a welded flange transition. For spans less than 100 feet (30 m) in length, a savings of 500 lbs (230 kg) of flange material will generally offset the cost of a welded flange transition. Use a maximum of two flange transitions or three plate sizes in a particular field section. This case usually applies in the negative moment region. In positive moment areas, one flange size can often be carried through the field section. Bolted field splices in continuous girders are good locations for changing flange geometry as this eliminates a welded butt splice.
- Limit the number of different plate thickness used in a particular bridge or group of bridges within a project. The amount of a particular plate thickness that the fabricator can order is directly related to the unit cost of the material. The lightest steel bridge is not necessarily the most economical. Consideration must be given to the cost of fabrication processes in order to realize an economical design. For metric projects, refer to the Metric Structural Steel Special Provision for typical plate thicknesses.
- If the girder length exceeds 135 feet (41.1 m), detail the plans for a bolted field splice. When transitioning the web plate thickness at a field splice, increment the web thickness at least $^1/_8$ inch (3 mm) so that $^1/_{16}$ inch (1.5 mm) fill plates may be used.

Diaphragms

General

For staged construction in all steel superstructures, with the exception of horizontally curved girder superstructures, do not detail intermediate diaphragms in the staging bay if at least three beams or girders lie on both sides of the longitudinal joint. For continuous steel superstructures do not detail interior bent diaphragms in the staging bay. When required for staged construction, diaphragms in the bay containing a longitudinal construction joint shall be detailed with a bolted connection between the diaphragm and the connector plates. Provide vertical slots in one connector plate and horizontal slots in the opposing connector plate to allow for field adjustment. Make the slots 1 inch (25 mm) by 1 ½ inch (40 mm) and detail structural plate washers. Place the following note on the plans:

> ***Nuts on bolts for connecting diaphragm to connector plate shall be left loose for purpose of adjustment until both sides of slab have been poured.***

For both normal crown and superelevated bridges, detail the diaphragm parallel to the bridge deck.

For economical reasons, provide uniformity in the diaphragm member sizes and types used on a bridge or throughout a project, whenever practical.

For integral abutment bridges, do not detail a diaphragm at the abutment.

Bent and End Bent Diaphragms

At the end bents and interior bents of simple spans, use steel diaphragms with ¾" (19.05 mm) ϕ shear studs anchored into a concrete end beam. See Figures 6-93 and 6-94. In the bent diaphragms show the 'K' bars going over the beams or girders. If the concrete diaphragm is wider than 2 feet (610 mm), use three #16 'K' bars equally spaced at the bottom of the concrete diaphragm.

For rolled beams, use C 12x20.7 (C 310x31) channels for 27 inch (690 mm) beams, C 15x33.9 (C 380x50) channels for beams 30 inches (760 mm) through 33 inches (840 mm), and MC 18x42.7 (MC 460x64) channels for beams 36 inches (920 mm) deep. For details see Figures 6-95, 6-96 and 6-97.

For plate girders less than 36 inches (920 mm) deep, Figure 6-97 may be used if the connector plate is detailed as in Figure 6-101, with the connector plate welded to the top and bottom flange. For plate girders 36 inches (920 mm) through 48 inches (1220 mm) deep, end bent and interior bent diaphragms shall be as shown in Figure 6-98. For plate girders greater than 48 inches (1220 mm) deep, diaphragms must be designed on an individual basis. These should be detailed similar to Figures 6-99 and 6-100. The dimension between the bottom flange and the diaphragm or bracing member must be determined by the detailer. Show the minimum length and the weld size required for gusset plate attachments.

For continuous spans, detail either a cross-frame or K-frame type interior bent diaphragm similar to those of Figures 6-106, 6-107, 6-108 and 6-109. For skews between 70º and 110º, place the interior bent diaphragms along the skew. For all other skews, place the interior bent diaphragms perpendicular to the girders and use one bearing stiffener as a connector plate.

Intermediate Diaphragms

Place the intermediate diaphragms normal to the beams or girders for all skews. A maximum spacing of 25 feet (7.6 m) shall be used for all intermediate diaphragms.

For rolled beam simple spans, use C 12x20.7 (C 310x31) channels for 27 inch (690 mm) beams, C 15x33.9 (C 380x50) channels for beams 30 inches (760 mm) through 33 inches (840 mm), and MC 18x42.7 (MC 460x64) channels for beams 36 inches (920 mm) deep. For details see Figures 6-102, 6-103 and 6-104.

For rolled beam continuous spans, use C 15x33.9 (C 380x50) channels for all beams less than 36 inches (920 mm) and MC 18x42.7 (MC 460x64) for beams 36 inches (920 mm) deep as shown in Figures 6-103 and 6-104.

For plate girders less than 36 inches (920 mm) deep, Figure 6-104 may be used if the connector plate is detailed as in Figure 6-101, with the connector plate welded to the top and bottom flange. For plate girders 36 inches (920 mm) through 48 inches (1220 mm) deep, diaphragms shall be detailed as shown in Figure 6-105. Intermediate diaphragms for girders 49 inches (1245 mm) through 60 inches (1525 mm) deep shall be as shown in Figure 6-106. Cross-frames for girders greater than 60 inches (1525 mm) deep must be designed on an individual basis. These should be detailed similar to Figures 6-107, 6-108 and 6-109. The dimension between the bottom flange and the cross-frame bracing member must be determined by the detailer. Show the minimum length and the weld size required for the cross-frame, gusset plate or lateral bracing attachments.

When traffic must be maintained during construction beneath a bridge with plate girders greater than 60 inches (1525 mm) in depth, provide both cross-frames of Figures 6-107 and 6-108 in the plans. Label the cross-frame with the welded gusset plates, Figure 6-107, as an optional intermediate diaphragm. Place the following note on the plans:

At the Contractor's option, the diaphragm with the welded gusset plates may be used in lieu of the diaphragm with bolted angles at no additional cost to the Department.

Lateral Bracing

When required or suggested by the AASHTO LRFD Bridge Design Specifications, top flange lateral bracing should be detailed similar to the details in Figures 6-100 or 6-109, 6-112 and 6-111. Lateral bracing shall be designed on an individual basis.

Stiffeners and Connector Plates

For simply supported ends of rolled beam spans, bearing stiffeners shall be provided on both sides of the web for interior beams and the inside of the web for exterior beams. Place the following note on the plans:

Stiffeners are not required on the outside of exterior beams.

These bearing stiffeners shall serve as connector plates for the diaphragms and shall be detailed parallel to the end of the beam. Therefore, when the ends of the beam are beveled for grade, the end stiffeners will be vertical. If the ends of the beam are not beveled, the end stiffeners shall be normal to the beam flange. Typically, these stiffeners shall have widths such that they provide approximately ½ inch (13 mm) distance to the edge of flange. The stiffener thickness shall not be less than $^{1}/_{12}$ its width, nor less than $^{3}/_{8}$ inch (9 mm).

For plate girders, the bearing stiffeners shall be designed according to the AASHTO LRFD Bridge Design Specifications. For the details of bearing stiffeners, see Figure 6-112. For skews between 70° and 110°, the bearing stiffener may be placed along the skew and used as a connector plate for bent diaphragms. In this case, detail the bearing stiffener mill to bear at the bottom and provide fillet welds at the top and bottom of the stiffener. When the bearing stiffener is used as a connector plate, provide a minimum width and thickness of the plate on the plans; do not provide a width dimension as the fabricator will determine the width. Place the following note under the bearing stiffener detail on the plans:

Bearing stiffener may require coping if wider than bottom flange.

At continuous bents, check the fatigue stress range for a Category C fatigue detail as per the AASHTO LRFD Bridge Design Specifications. For other skews, detail the diaphragms approximately 1'-0" (300 mm) from the center of the bearing to clear the bearing stiffener and detail a separate connector plate, see Figure 6-101.

When detailing connector plates, do not provide a width dimension as the fabricator will determine the width. Stiffener or connector plate details shall include the weld termination details of Figure 6-113. The welded connections for stiffeners or connector plates to beam or girder webs shall be in accordance with Figure 6-114.

When the skew is less than 60° or greater than 120°, a bent gusset plate shall be used to join the diaphragm member with the connector plate welded perpendicular to the web. The gusset plate shall be the same thickness as the connector plate. The number of bolts used to connect the gusset plate to the connector plate shall be consistent with the connections of Figures 6-95, 6-96, 6-97, 6-98, 6-99 and 6-100 or as required by design. The height of the gusset plate and welds shall be detailed as shown in the example of Figure 6-115. Do not detail the gusset plate width or bend radius.

Intermediate Stiffeners

Intermediate stiffeners for plate girders shall be designed according to the AASHTO LRFD Bridge Design Specifications. The use of transversely stiffened webs shall be based on the depth of the web plate. When designing girder webs less than 50 inches (1270 mm) in depth, unstiffened webs are economical while for depths 50 inches (1270 mm) or greater, partially stiffened webs are more cost effective. The determination of how much of the web is to be stiffened must be made by considering the labor cost of the stiffener versus the cost of the web material saved. For relative cost analyses, assume that the cost of the stiffener steel is four times greater than that of the web. It is suggested that designers select a web thickness such that a minimum number of intermediate stiffeners are required.

For interior girders, intermediate stiffeners may be placed on alternating sides of the web. For exterior girders the intermediate stiffeners shall be placed on the inside of the web only. For intermediate stiffener details, see Figure 6-112.

Longitudinal stiffeners, due to their high fabrication cost and poor fatigue performance, shall be considered for only those spans greater than 250 feet (76.2 m) in length and shall not be used unless approved by the State Bridge Design Engineer. If required, longitudinal stiffeners shall be uninterrupted by placing the longitudinal stiffener on the side of the web opposite the transverse stiffeners.

Shear Connectors for Composite Action

For all beams and girders designed for composite action, use ¾" (19.05 mm) ϕ by 5 inch (127 mm) minimum length studs. For proper slab penetration and concrete cover, the shear connectors shall be detailed to satisfy the AASHTO LRFD Bridge Design Specifications. Therefore, consideration shall be given to increasing the length of the connectors when an increased buildup is required.

For shear connectors attached to the channel bent diaphragms, use ¾" (19.05 mm) ϕ by 4 inch (102 mm) stud length. See Figure 6-116 for details.

High Strength Bolts

High strength bolts shall be shown on the plans for all field bolted connections including diaphragms and beam or girder splices.

When AASHTO M270 Grade 50W (345W) steel is specified, the high strength bolts, nuts and washers shall conform to AASHTO M164 Type 3.

Place the following note on the plans:

> ***Tension on the AASHTO M164 bolts shall be calibrated using direct tension indicator washers in accordance with Article 440-8 of the Standard Specifications.***

Bolted Field Splices

Bolted field splices shall be designed as per the AASHTO LRFD Bridge Design Specifications. Flange and web splices shall be symmetrical about the centerline of the splice.

Bolted field splices should only be detailed when required to limit the girder field section lengths to 135 feet (41.1 m) or when known shipping limitations exist. Do not detail an additional bolted field splice if girder symmetry about the bents is the sole consideration. In this case, a permitted bolted field splice may be beneficial to the Contractor and the following note should be placed on the plans:

> ***A bolted field splice will be permitted in the girders in Span __. If a field splice is used, it shall be made entirely at the Contractor's expense and no additional measurement or payment will be made for the additional materials required. The location, details, and splice material will be subject to the approval of the Engineer.***

The contact surface of bolted parts to be used in the slip-critical connections shall be Class C for AASHTO M270 Grade 50 (345) steel or Class B for AASHTO M270 Grade 50W (345W) steel. Design these connections with a minimum of $^1/_8$ inch (3 mm), preferably ¼ inch (6 mm), additional edge distance beyond the AASHTO LRFD Bridge Design Specification requirements to provide greater tolerance for punching, drilling and reaming. Use a 3 inch (75 mm) minimum distance from the centerline of the web splice to the first row of bolts. See Figure 6-117.

Charpy V-Notch Test

All structural steel furnished for main beam and girder components subject to tensile stresses shall meet requirements of the longitudinal Charpy V-Notch Test.

For rolled beams, place the following note on the plans:

A Charpy V-Notch Test is required on all beam sections, cover plates and splice plates as shown on the plans and in accordance with Article 1072-9 of the Standard Specifications.

For simple span plate girders, place the following note on the plans:

A Charpy V-Notch Test is required for web plates, bottom flange plates, bottom flange splice plates and web splice plates** (if used) **for all girders and in accordance with Article 1072-9 of the Standard Specifications.

For continuous plate girders, see Figure 6-118 for Charpy V-Notch Test notes and the girder components that require testing.

For integral end bents, determine the length of the top flange subject to tensile stresses by re-running the girder design with fixed ends for live loads. See Figure 6-118.

For horizontally curved girders, place the following note on the plans:

For Charpy V-Notch Test, See Special Provisions.

Design Details

For steel beams on grade, the ends of the beams or girders should be beveled to maintain concrete cover. A correction should be made to the length between the bearings of beams and girders on a grade when the sloped distance exceeds the horizontal distance by more than ¼ inch (6 mm). Show the sloped length in parentheses on the bottom flange detail or over the tapered girder elevation. Place the following note on the plans:

End of beams and girders shall be plumb.

For continuous rolled beam spans, include in the plans a designation of the regions where the top flange is in tension and include the following note:

No welding of forms or falsework to the top flange will be permitted in this region.

When detailing welded steel girders, show the flange and web butt joint welding details in accordance with Figure 6-92. Shop web splices should not be located within 2'-0" (600 mm) of a shop flange splice. In negative moment regions of continuous girders, provide transverse stiffeners in lieu of detailing a web shop splice to transition to a thicker web. Indicate where the additional shop web and flange splices will be allowed by placing the following note on the plans:

Shop splices are permitted to limit the maximum required flange piece lengths to 60 feet** (18 m) **and web piece lengths to 45 feet** (14 m)**. Permitted flange and web shop splices shall not be located within 15 feet** (4.5 m) **of maximum dead load deflection** (nor within 15 feet (4.5 m) of intermediate bearings of continuous units)**. Keep 2 feet** (600 mm) **minimum between web and flange shop splices. Keep 6"** (150 mm) **minimum between connector plate or transverse stiffener welds and web or flange shop splices.

Deflections and Cambers

Dead Load Deflections

Deflections and cambers for all rolled beams and plate girders with spans less than 100 feet (30.5 m) should be shown at the 10^{th} points. For plate girders with any span longer than 100 feet (30.5 m), provide deflections and cambers at 20^{th} points. If any plate girder span exceeds 200 feet (61 m), deflections and cambers shall be shown at 30^{th} points.

Show the deflections for these points in feet (meters) to three decimal places. The deflections shall be shown for both interior and exterior beams and girders. Tabulate the deflections, vertical curve ordinates, and superelevation ordinate as follows:

Deflection due to weight of steel	= ______________
Deflection due to weight of slab	= ______________
Deflection due to weight of rail	= ______________
Total Dead Load Deflection	= ______________
Vertical Curve Ordinate	= ______________
Superelevation Ordinate	= ______________
Camber due to dissipation resulting from heat curving (curved girders only)	= ______________
Required Camber	= ______________

Deflections, ordinates and cambers shall be shown in feet (meters) to three decimal places, except the Required Camber, which shall be shown to the nearest sixteenth of an inch (millimeter).

When a slab contains several pours, additional diagrams should provide the deflections at the appropriate points due to each individual pour. These diagrams are used by the Contractor to determine ordinates for grading with a longitudinal screed and are required for the interior beams or girders only. Since longitudinal screeds are disallowed for poursexceeding 85 feet (26 m) in length, it is not necessary to provide pour deflection diagrams for pours exceeding this limit.

The superelevation ordinate is required when a bridge is on a horizontal curve or spiral alignment. It is also required on the spans of tangent bridges that have a variable superelevation. The superelevation ordinate is generally deducted from the total dead load deflection but must, in special cases, be added to the total dead load deflection. The superelevation ordinate should not be combined with the vertical curve ordinate but shown separately in the table of dead load deflections. The superelevation ordinates may be obtained from the computer program “Construction Elevations - Bottom of Slab Elevations Along Beams”.

The camber due to dissipation resulting from heat curving is required for horizontally curved steel girders only, and shall be determined in accordance with the AASHTO Standard Specifications.

Special Design Procedures for Non-Composite Dead Load Deflections

Computation of non-composite dead load deflections shall be based on the procedure outlined in Section 2-2 of this manual.

Camber of Continuous Spans

In addition to the deflection curves for continuous spans, camber curves should be shown and labeled as “Schematic Camber Ordinates”. On vertically curved bridges use the following note:

Slope for the zero camber base line varies.

Beam Cambers (Rolled Beams)

If the total dead load deflection plus vertical curve and superelevation ordinates is less than ¾ inch (19 mm), do not show a “Required Camber”. Place the following note on the plans:

No shop camber required, turn natural mill camber up.

Otherwise, detail simple span beams to be cambered to the nearest $^1/_{16}$ inch (1 mm). When one beam in a span requires camber, detail all of the beams in that span with camber.

Beam Camber on Sag Vertical Curve Bridges (Rolled Beams)

In preparing the table of dead load deflections and camber, careful consideration should be given to insure that no thinning of the slab occurs in a sag vertical curve. When the net deflection (dead load deflection minus any superelevation ordinate) exceeds the sag vertical curve ordinate by more than ¼ inch (6 mm), the natural mill camber shall be turned up in the usual manner. However, if the net deflection equals or exceeds the sag vertical curve ordinate by less than ¼ inch (6 mm), call for the natural mill camber to be turned downward. If the sag vertical curve ordinate is greater than the net deflection, the bridge seats should be adjusted accordingly and the plans should call for the natural mill camber to be turned downward.

Live Load Deflection

For the purpose of computing live load deflections, all beams or girders in a typical section may be assumed to act together and therefore deflect equally.

Construction Practices

Place the following applicable notes on the plans:

Structural steel erection in a continuous unit shall be complete before falsework or forms are placed on the unit.

Previously cast concrete in a continuous unit shall have attained a minimum compressive strength of 3000 psi *(20.7 MPa)* ***before additional concrete is cast in the unit.*** (This note should be reworded when simple spans have multiple pours.)

Barrier rail in a continuous unit shall not be cast until all slab concrete in the unit has been cast and has reached a minimum compressive strength of 3000 psi *(20.7 MPa)****.***

Barrier rail in each span shall not be cast until all slab concrete in that span has been cast and has reached a minimum compressive strength of 3000 psi *(20.7 MPa)****.*** (This note should be used for all simple spans.)

Direction of casting deck concrete shall be from the fixed bearing end toward the expansion bearing end of the span. (For simple span steel girders with a total expansion length of 150 feet (46 m) or greater)

The Contractor may, when necessary, propose a scheme for avoiding interference between metal stay-in-place form supports or forms and beam/girder stiffeners or connector plates. The proposal shall be indicated, as appropriate, on either the steel working drawings or the metal stay-in-place form working drawings.

Horizontally Curved Plate Girders

General

Curved girder bridges shall be used on special instructions only when the combination of degree of curvature and length of span make it impractical to utilize straight chord girders on a curved bridge alignment.

The effects of curvature must be accounted for in the design of steel superstructures where the girders are horizontally curved. The magnitude of the effect of curving girders is primarily a function of radius, span, diaphragm spacing, and to a lesser degree, girder depth and flange proportions. Two effects of curvature develop in these bridges that are either nonexistent or insignificant in straight girder bridges. First, the general tendency is for each girder to overturn, thereby transferring both dead and live load from one girder to another in the cross section. The net result of this load transfer is that some girders carry significantly more load than others. This load transfer is carried through the diaphragms. The second effect of the curvature is the concept of lateral flange bending. This bending is caused by torsion in the curved members that is almost completely resisted by horizontal shear in the girder flanges. These bending stresses either compound or reduce the vertical bending stresses.

Follow the AASHTO LRFD Bridge Design Specifications when designing horizontally curved girders.

Details

All curved girder bridges shall be continuous and designed for composite action. All diaphragms shall be placed radially and spaced so as to limit the flange edge stresses due to lateral flange bending.

Diaphragms are primary structural members, that must be designed to carry the total load transferred at each diaphragm location, including their connections to the girders. For sharply curved structures, full depth diaphragms shall have connections to the girder webs and flanges that transfer the flange shears to the diaphragm without over stressing the girder web to flange weld. Transverse welds on the girder flanges will be permitted if the allowable stresses are reduced as per the fatigue criteria pertaining to the connection details.

Special consideration must be given to the expansion and girder end rotation characteristics of curved steel member bridges. On a curved steel member bridge, expansion between the fixed and expansion bearings will occur along a chord between the two bearing points. It is necessary to provide expansion bearings that will permit horizontal movement along this chord. Both the fixed and expansion bearings must provide for end rotation about a radial line.

The splices in flanges of curved girders must be designed to carry both the lateral bending stresses as well as vertical bending stresses in the flanges.

Follow the specifications for the allowable flange tip stress and fatigue stress.

6-7 Bearings and Anchorage

General The use of 50 durometer elastomeric bearings for all bridge types is preferred. For those instances where the use of elastomeric bearings is impractical, consideration shall be given to the use of pot or TFE bearings.

The allowable bearing stress on concrete shall be in accordance with the AASHTO LRFD Bridge Design Specifications. The bearing pressure on the TFE sliding surface shall not exceed 3000 psi (20.7 MPa) for TFE expansion bearing assemblies. Pot bearings are designed by the supplier according to the loads and movement specified on the structure plans.

With the exception of pot bearings, steel bearing plates used with steel beams or plate girders shall be AASHTO M270 Grade 50W (345W) or 50 (345), or at the designers option Grade 36 (250). In accordance with the Standard Specifications, steel bearing plates for prestressed girders shall be AASHTO M270 Grade 36 (250) and all bearing plates, bolts, nuts and washers used with prestressed girders shall be galvanized.

For TFE expansion bearing assemblies, all bearing plates shall be galvanized except the plates receiving the TFE pad or stainless steel sheet. The plates receiving the TFE pad or stainless steel sheet shall be commercially blast cleaned and, except for the areas with special facing, shall be painted in accordance with the Special Provisions.

All steel in pot bearings shall be AASHTO M270 Grade 50W (345W). The plates in the pot bearing assemblies shall be commercially blast cleaned and, except for the areas with special facing, shall be metallized in accordance with the Special Provisions.

Detail a $^{3}/_{16}$ inch (5 mm) preformed bearing pad under steel masonry plates.

Elastomeric Bearing Pads

Prestressed Concrete Cored Slabs

The use of level, unreinforced pads is preferred. The pads shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications. In general, use 6 inch (150 mm) by $^{5}/_{8}$ inch (16 mm) pads as a minimum and detailpad thicknesses in increments of $^{1}/_{8}$ inch (3 mm) . Place the details on Standard PCS3. It may be necessary to slope the cap to allow the use of level pads, see Section 7-1 “Sloped Caps”.

Slab on Beams or Girders

The use of steel reinforced elastomeric pads in combination with steel sole plates is preferred. Use a sole plate thickness of 1 ¼ inches (32 mm), unless the sole plate is beveled or fill plates are required. Incorporate any required fill plate thickness up to 1 inch (25 mm) into the sole plate - do not use separate fill plates. When the grade plus final in-place camber exceeds 1%, bevel the sole plate to match the grade plus final camber. Use 1 inch (25 mm) minimum clearance between the edge of the elastomeric bearing and the edge of the sole plate in the direction parallel to the beam or girder. For steel beams or girders, use ½ inch (13 mm) minimum clearance between the edge of the elastomeric bearing pad and the steel sole plate in the direction perpendicular to the beam or girder.

For steel beams or girders, refer to Standards EB1 and EB2 for standard pad Types I through VI. These standard pads satisfy the allowable rotation criteria for the following span capacities and load ratings :

Steel Beams or Girders		
Pad Type	Maximum Length of Superstructure Expanding at the Bearing	Maximum DL plus LL (Service Load, No Impact)
I	85 feet (27 m)	91 kips (396 kN)
II	125 feet (37 m)	119 kips (557 kN)
III	150 feet (44 m)	144 kips (674 kN)
IV	175 feet (52 m)	184 kips (809 kN)
V	197 feet (56 m)	200 kips (943 kN)
VI	210 feet (65 m)	262 kips (1134 kN)

If the design values shown in the above table are exceeded either by movement or load, increase the hardness to 60 durometer and check the elastomeric bearings in accordance with the AASHTO LRFD Bridge Design Specifications. If 60 durometer hardness is acceptable, place the following note on plans:

Elastomer in all bearings shall be 60 durometer hardness.

If the design values for 60 durometer hardness are exceeded by either movement, load or rotation, pot bearings or TFE bearings shall be used. If the design values are exceeded at the fixed location only, a fixed bearing assembly may be used here in conjunction with elastomeric bearings at the expansion location. See Figure 6-130 for details.

Taper the bottom flange to 12 inches (300 mm) at the ends of plate girders as required to accommodate the anchor bolt gage for Elastomeric Pad Type I and II. For Elastomeric Pad Type III-VI, taper the bottom flange to 15 inches (380 mm) at the end of the plate girder.

When elastomeric bearings pads are used at expansion ends of steel girders with spans greater than 120 feet, detail grout cans to accommodate placement of anchor bolts. Place the following note on the plans:

The contractor's attention is called to the following procedures to accommodate girder translation and end rotation:

1. Once the deck has cured, the girders shall be jacked and the sole plate and elastomeric bearing slots shall be centered as nearly as practical about the bearing stiffener . This operation shall be performed at approximately 60°F (16°C).

2. ***After centering the slots about the anchor bolts, the sole plates shall be field welded to the girder flanges and anchor bolts grouted. The contractor may propose alternate methods provided details are submitted to the Engineer for review and approval.***

In addition place the following note on the appropriate bent or end bent drawing(s):

Epoxy coat the [end] bent cap after adjustments are made to bearings and anchor bolts are grouted.

For prestressed concrete girders, refer to Standards EB3 and EB4 for standard pad Types II through VII. These standard pads satisfy the allowable rotation criteria for the following span capacities and load ratings:

Prestressed Concrete Girders		
Pad Type	Maximum Length of Superstructure Expanding at the Bearing	Maximum DL plus LL (Service Load, No Impact)
II	145 feet (44 m)	82 kips (366 kN)
III	145 feet (44 m)	115 kips (512 kN)
IV	175 feet (53 m)	137 kips (611 kN)
V	200 feet (61 m)	180 kips (801 kN)
VI	229 feet (70 m)	211 kips (936 kN)
VII	249 feet (76 m)	264 kips (1174 kN)

If the design values shown in the above table are exceeded either by movement or load, individual designs and details in accordance with the AASHTO Standard Specifications shall be used. It is more economical to maintain the plan view dimensions of the standard pads and adjust the pad thickness or durometer hardness of the elastomer. If 60 durometer hardness is used, place the following note on plans:

Elastomer in all bearings shall be 60 durometer hardness.

When elastomeric bearings are used on continuous for live load deck slabs, both bearings at the continuous bents shall be fixed.

Payment

Payment for elastomeric bearings shall be shown on the Total Bill of Material at the lump sum price for “Elastomeric Bearings”. Payment for steel sole plates used with plate girders or rolled beams is included in the pay item for

"Structural Steel". Payment for steel sole plates used with prestressed girders is considered incidental to the cost of the girder.

Pot Bearings

When pot bearings are used, place the vertical and horizontal design load requirements on the plans, see Figure 6-124.

- In Seismic Performance Zone 1, the horizontal load for pot bearings shall be 10% of the total load or 20% of the dead load, whichever is greater.
- For Seismic Performance Zone 2, the horizontal load for pot bearings shall be the lateral load obtained from a seismic analysis (SEISAB) or 10% of the total load, whichever is greater.

Refer to Standard PB1 and Figures 6-124, 6-125, 6-126 and 6-127 for plan details such as masonry plate size, anchor bolt gage, and overall bearing height. Show the plan dimensions and thickness of the masonry plate and the width of the sole plate in the direction perpendicular to the beam or girder. The sole plate shall extend 1 inch (25 mm) beyond both sides of the bottom flange. Do not detail the width of the sole plate in the direction parallel to the girder or the thickness of the sole plate. Use the anchor bolt gage from Figure 6-119 to check for conflicts with reinforcing steel in the bent cap.

Align the masonry plate so that the centerline of the plate is normal to the bent cap. Bevel the sole plates to match the final grade of the bottom flange at the location of the bearing and show the slope percentage above the sole plate details. For expansion bearings, use 4 inch (102 mm) grout cans for anchorage. See Figures 6-124, 6-125, 6-126 and 6-127 for typical details.

On curved girder bridges, expansion occurs along a chord drawn between the fixed and expansion bearings. This angle shall be shown on the plans so the pot bearings can be set correctly in the field.

For an example of pot bearings, see Figure 6-128.

Place the appropriate notes on the plans:

The Contractor shall adjust the girder buildups as necessary to incorporate a maximum permissible variation in pot bearing depth of *½ in* ***(13 mm), see Special Provision for Pot Bearings.***

Sole plates should be welded to beam flanges and anchor bolts should be grouted before falsework is placed.

At all points of support in Spans _____, nuts for anchor bolts shall be tightened finger tight and given an additional 1/4 turn. The thread of the nut and bolt shall then be burred with a sharp pointed tool.

When welding the sole plate to the girder, use temperature indicating wax pens, or other suitable means, to ensure that the temperature of the bearing

does not exceed 250°F** (121°C). **Temperatures above this may damage the TFE or elastomer.

Disc Bearings shall be permitted as an option to pot bearings. When pot bearings are required, place the following note on the plans:

The Contractor may substitute Disc Bearings for the Pot Bearings shown. For Optional Disc Bearings, see Special Provisions.

Payment for pot bearings shall be shown on the Total Bill of Material at the lump sum price for "Pot Bearings".

TFE Bearings

When TFE bearings are used, refer to Standard TFE1 and Figure 6-129 for typical details. Use 4 inch (102 mm) grout cans at expansion assembly locations. At fixed locations, use a curved sole plate with a 2'-0" (610 mm) radius and a flat masonry plate with a thickness of 1 ¼ in (32 mm), unless the sole plate is beveled or fill plates are required. See Figure 6-130.

Size the TFE pad based on the bearing loads. Limit the compressive stress to 3000 psi (20.7 MPa) including any stress due to eccentric loading. Use a ½ inch (13 mm) minimum clearance between the edge of the TFE pad and the edge of the stainless steel sheet in all directions. The length of the stainless steel sheet in the direction parallel to the girder shall also be based on the anticipated movement due to thermal effects and end rotation, rounded up to the next inch (20 mm). For the temperature setting table and details to be shown on the plans, see Figure 6-124.

When the grade of the girder at the location of the bearing due to roadway grade and final camber is between 4% and 8%, bevel the top of the curved sole plate 1 inch (25 mm) in 24 inches (610 mm). When the grade of the girder at the location of the bearing is greater than 8%, bevel the top of the curved sole plate to match the grade of the girder. When fill plates are required, place the following note on the plans:

At the Contractors option, fill plates** (where used) **may be combined with masonry plates.

Place the appropriate notes on the plans:

For TFE Expansion Bearing Assemblies, see Special Provisions.

All bearing plates shall be AASHTO M270 Grade _______.

At fixed points of support, nuts for anchor bolts shall be tightened finger tight and then backed off 1/2 turn. The thread of the nut and bolt shall then be burred with a sharp pointed tool.

Anchor bolts should be grouted before falsework is placed.

The 1 ½" (38.10 mm) ϕ pipe sleeve shall be cut from Schedule 40 PVC plastic pipe. The PVC pipe shall meet the requirements of ASTM D1785.

No separate payment will be made for the pipe sleeves. Payment shall be included in the lump sum contract price bid for "TFE Expansion Bearing Assemblies".

Cambered girder lengths shall be adjusted and bearings are to be placed on the cambered girder so as to be aligned with the anchors after the dead load deflection has occurred. Shop drawings shall be prepared accordingly.

The last note shall be modified and placed on rolled beam spans where the dead load deflection and slope produces a change in length of more than ¼ inch (6 mm).

Payment for TFE bearing assemblies shall be shown on the Total Bill of Material at the lump sum price for "TFE Expansion Bearing Assemblies". Payment for fixed bearing assemblies used in conjunction with TFE expansion bearings shall be included in the pay item for "Structural Steel".

Anchorage

For prestressed girder spans, use 2" (50.80 mm) ϕ anchor bolts set 18 inches (460 mm) into the concrete cap. The anchor bolt gage for sole plates shall be computed as the bottom flange width plus 6 inches (150 mm).

For cored slab spans, provide 1" (25 mm) ϕ holes in fixed end bearing pads and 2 ½" (64 mm) ϕ holes in expansion end bearing pads for #6 (#19) dowels. Dowels shall be 1'-6" (460 mm) long set 9 inches (230 mm) into the concrete cap.

For rolled beam and plate girder spans with elastomeric bearings, use 1 ¾" (44.45 mm) ϕ anchor bolts, set 18 inches (460 mm) into the concrete cap. The anchor bolt gage for elastomeric bearings shall be as shown on Standards EB1 and EB2.

For TFE expansion bearing assemblies, use 1 ½" (38.10 mm) and 1 ¾" (44.45 mm) ϕ anchor bolts set 15 inches (380 mm) into the concrete cap for the expansion and fixed ends, respectively. The anchor bolt gage for sole plates shall be computed as the bottom flange width plus 5 inches (130 mm). This may be varied to suit special conditions.

For pot bearings, use 1 ½" (38.10 mm) ϕ anchor bolts set 15 inches (380 mm) into the concrete cap.

The required length of the anchor bolt shall be the required projection plus the embedment length in the concrete cap. Compute the amount of projection of anchor bolts required by adding the thickness of all materials through which the bolt must project plus:

- 2 $^{1}/_{8}$ inches (54 mm) for 1 ½" (38.10 mm) ϕ bolts used with pot bearings, rounded to the next $^{1}/_{8}$ inch (1 mm).
- 2 ¼ inches (60 mm) for 1 ½" (38.10 mm) ϕ bolts, except when used with pot bearings, and 1 ¾" (44.45 mm) ϕ bolts rounded up to next ½ inch (10 mm).
- 2 ½ inches (65 mm) for 2" (50.80 mm) ϕ bolts rounded up to next ½ inch (10 mm).

For elastomeric bearings, detail the anchor bolt length on both the applicable EB Standard Drawing and the substructure unit sheet.

Except when detailing pot bearings, if the required projections on a given substructure unit vary by 1 inch (30 mm) or less, show the projection for all bolts as the maximum required on that substructure unit.

Bearing Plate Details

For surface finish details, see Figure 6-131.

At the fixed end of prestressed girder spans, use 2 $^{7}/_{16}$" (62 mm) ϕ holes in the sole plates.

At the fixed end of rolled beam spans, use 1 $^{15}/_{16}$" (49 mm) ϕ holes in the sole plates and the elastomeric bearing pads.

At the fixed end of plate girder spans, use 1 $^{15}/_{16}$" (49 mm) ϕ holes in the masonry plate and elastomeric pad and 1 $^{15}/_{16}$" (49 mm) by 2 ¼ inch (57 mm) slots at the top tapered to a 1 $^{15}/_{16}$" (49 mm) ϕ hole at the bottom of the sole plate.

At the expansion end, the slot size should be determined according to the amount of expansion and end rotation anticipated. See Figure 6-132 for the required slot size.

Sole Plate Welds

Show the weld size for the connection between the sole plate and the bottom flange for all bearing types.

The end of prestressed girders, rolled beams or plate girders should extend at least 1 inch (25 mm) beyond the edge of the sole plate.

The sole plate shall be field welded to the embedded plate in the prestressed girder with a $^{5}/_{16}$ inch (8 mm) minimum groove weld. For the expansion ends of steel beams or girders on elastomeric bearings, detail a field weld between the sole plates and the flanges. Place the following note on the plans:

> ***When field welding the sole plate to the girder flange, use temperature indicating wax pens, or other suitable means, to ensure that the temperature of the sole plate does not exceed 300ºF** (149ºC)**. Temperatures above this may damage the elastomer.***

For pot bearings, detail a field weld between the sole plate and the bottom flange.

Bridge Ratings

All girders designed in accordance with the AASHTO LRFD Specifications shall be rated in accordance with the AASHTO Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR).

Rating shall be performed for all applicable strength and service limit states, including the optional checks. Perform an inventory and operating rating for the HL-93 design live load, and legal load rating for all of North Carolina's notional legal trucks. The Bridge Maintenance Unit maintains the list of NC legal truck configurations. Bridges on the national highway system (NHS) routes need not be rated for non-interstate NC legal trucks.

The rating for the exterior and interior girders shall be archived in the design folder. Show a summary of the controlling rating in the format show in the table below on the plans. Acceptable rating factors (RF) shall be greater than 1.0.

Bridge Type	Limit State	Design Load (HL-93)		Legal Load
		Inventory	Operating	
Steel	Strength I			
	Service II			
	Fatigue			
Prestressed Concrete	Strength I			
	Service III			

CHAPTER 7
SUBSTRUCTURES

7-1 Bent Caps

General The guidelines of this section pertain to the cast-in-place concrete caps of all end bents and interior bents.

For substructures at Corrosive Sites, see Section 12-12.

Plan Layout

Show the control line for the interior bent or end bent. For interior bents, if the control line is offset from the centerline of the bent due to eccentric loading, place the following note on the bent drawings:

The Contractor's attention is called to the fact that the centerline joint in the deck slab (control line) is offset from the centerline bent.

The control line shall not be offset from the centerline of the bent if the calculated offset is less than 3 inches (75 mm).

Show the work point and workline and provide all bent dimensions as measured from this point or line.

Show all substructure elevations to three decimal places.

Anchor Bolts

The location and the required anchor bolt projection above the bridge seats shall be shown for all substructure units. See Section 6-6 "Anchorage" for anchor bolt projection requirements. Where pipe inserts for anchor bolt adjustment are required, show the location of the swedged anchor bolts and the 4" (102 mm) ϕ pipe inserts, and place the following note on the plans:

For pipe insert details, see Bearings Sheet.

Construction Joints

In general, use a construction joint when the cap length exceeds 90 feet (30 m). Locate this construction joint within 2 - 3 feet (1 m) of a column or pile.

Minimum Cap Clearances

The following guidelines shall be followed in determining the bent cap width:

- For steel superstructures, the distance from the side face or step of a concrete cap to the centerline of the anchor bolt shall not be less than 5 inches (125 mm), nor shall the distance to any edge or corner of an elastomeric bearing or masonry plate be less than 2 ½ inches (65 mm).
- For prestressed girder superstructures, the distance from the side face or step of a concrete cap to the centerline of the anchor bolt shall not be less than 5 ½ inches (140 mm), nor shall the distance to the elastomeric bearing be less than 2 ½ inches (65 mm).

Increase cap widths if necessary to provide these minimum dimensions. When it becomes necessary to lift rolled beam and prestressed girder spans for repair, Bridge Maintenance must use a hydraulic jack placed under the bent diaphragm. To accommodate this operation on severely skewed bridges, consideration shall be given to providing a minimum edge distance of 2 ½ inches (65 mm) to the edge of the jacking base plate. The jack base plate is usually 12 inches (305 mm) by 9 ½ inches (240 mm). Place the jack so that the 9 ½ inch (240 mm) dimension is normal to the centerline of the cap.

The following guidelines shall be followed in determining the bent cap length:

- For steel superstructures, the length of interior bent caps should provide a minimum of 9 inches (230 mm) from the edge or corner of the bearing plate to the end of the cap.
- For prestressed girder superstructures, the length of interior bent caps should provide a minimum of 9 inches (230 mm) from the anchor bolt to the end of the cap.
- For cored slab structures, both end bent and interior bent caps shall be detailed with a concrete lateral guide at the outside face of the exterior slab units, see Figure 7-1. Provide 1 ½ inch (38 mm) expansion joint material between cored slab and lateral guide.

Bridge Seat Elevations

In the computation of bridge seat elevations where metal plates bear on concrete, a $^{3}/_{16}$ inch (5 mm) thickness shall be included for the preformed pads used between the masonry plate and the concrete. These preformed pads are not used with elastomeric bearings.

If the elevation difference between any two adjacent bridge seats is:

- Less than $^{1}/_{8}$ inch (3 mm), use the lower elevation for both bridge seats.
- $^{1}/_{8}$ inch (3 mm) to less than 1 inch (25 mm), incorporate the difference into the sole plate thickness for elastomeric bearings and use the lower elevation for both bridge seats. For other bearing types, use a fill plate with the masonry

plate and allow the Contractor the option to combine the fill plate with the masonry plate and use the lower elevation for both bridge seats.

- 1 inch (25 mm) or greater, detail a step in the bent cap.

Reinforcement

Minimum reinforcement and spacing should be in accordance with the AASHTO LRFD Bridge Design Specifications and the following guidelines.

Main Steel

The minimum number and size of main bars for both top and bottom mats of bent cap reinforcing steel shall be as follows:

Cap Width	Reinforcing Steel
≤ 3'-0" (910 mm)	4 - #9 (#29) bars or equivalent
3'-0" (910 mm) - 4'-0" (1.22 m)	5 - #9 (#29) bars or equivalent
4'-0" (1.22 m) - 5'-0" (1.52 m)	6 - #9 (#29) bars or equivalent
5'-0" (1.52 m) - 5'-8" (1.73 m)	7 - #9 (#29)bars or equivalent

Stirrups

For shrinkage and temperature reinforcement, provide ‘U’ shaped stirrups in the ends of the cap. Place stirrups 6 inches (150 mm) from the cap faces and space at a maximum of 1'-6" (450 mm) both vertically and horizontally.

For end bents, space #4 (#13) or #5 (#16) stirrups according to the AASHTO LRFD Bridge Design Specifications using one ‘U’ shaped stirrup and one horizontal stirrup at each location.

For interior bents, invert alternate stirrups. The size and spacing of the stirrups should be according to the AASHTO LRFD Bridge Design Specifications. In addition, place #4 (#13) ‘U’ shaped stirrups at 6" (150 mm) centers beneath the bearing area of each beam or girder.

Step-Up Steel

Observe the following procedures when placing steel in the top of bent caps with stepped bridge seats:

- For caps in which the steel is placed horizontally, the top steel should be raised to a position as shown in Figure 7-2 when the distance from the centerline of the bar to the top of the cap exceeds 6 ½ inches (165 mm). If this distance is between 6 ½ inches (165 mm) and 12 inches (305 mm), it may be more appropriate to provide additional #4 (#13) bars, to match the number of top bars, as shown in the Sloped Cap detail of Figure 7-2.

- When the bottom of the bent cap is sloped, the top steel should be placed parallel to the bottom of the cap. The stirrups shall be detailed a clear distance of 2 inches (50 mm) below the critical point along the top of cap so that the stirrups might be of uniform detail throughout. Additional #4 (#13) bars, to match the number of main bars, should then be placed horizontally in the top of the cap where the distance from the centerline of the bar to the top of the cap exceeds 7 inches (180 mm). See Figure 7-2.

Sloped Caps

If the cap depth at opposite ends of both end bents and interior bents differ by more than 15 inches (380 mm), consideration shall be given to sloping the bottom of the cap along its length so that one stirrup height may be detailed throughout. When the bottom of the cap is sloped, slope the top of cap lengthwise as well.

To accommodate the use of plain, level bearing pads on cored slab structures, it may be necessary to slope the bridge seats transversely to account for grade and slab camber. Even for flat grades, note that the camber alone may necessitate the use of sloped seats.

Epoxy Protective Coating

When epoxy protective coating for concrete is used, the following note should be placed on the bent and/or end bent sheet:

> ***The top surface areas of the ________ caps shall be cured in accordance with the Standard Specifications except the Membrane Curing Compound Method shall not be used.***

All end bent caps shall receive epoxy protective coating. At an end bent where there is a backwall, the top surface area minus the area of the backwall shall be given the protective coating. The following note shall be placed on the plans:

> ***Backwall shall be placed before applying the Epoxy Protective Coating.***

At an end bent where a curtain wall is used, the top surface area of the cap shall be given the protective coating except that the Contractor may, but is not required to, coat the top surface area to be covered by the curtain wall.

Where there is an expansion joint in the bridge deck over the bent, the bent cap shall receive epoxy protective coating on the entire top surface area of the cap. The chamfer area is included in the top surface area as indicated in the Special Provisions.

Where elastomeric bearings are used, the epoxy protective coating shall not be applied to the area under the elastomeric bearings. Where steel bearings are used, the Contractor may, but is not required to, coat the areas under the bearings.

Do not apply epoxy protective coating to the bent caps of prestressed concrete cored slab structures.

7-2 Integral Abutments

General

In order to reduce maintenance problems associated with expansion joints, engineers shall consider eliminating joints on bridges by utilizing integral abutments at the end bents, and employing continuous or continuous for live load girders over interior bents wherever possible.

Girder bridges with the geometric properties listed below shall be detailed with integral abutments:.

- Tangent alignment.
- Skews between 70^o and 110^o, i.e. ($70^o \leq$ skew $\leq 110^o$).
- Vertical grade ≤ 5%.
- Girder height shall not exceed 6ft. (1.83m)
- Total bridge length shall not exceed:
  - 300ft. (91.44m) for steel girder bridges.
  - 400ft. (121.92m) for prestressed concrete girder bridges.

Some site conditions, such as very high rock lines, may not permit use of integral abutments. For those situations, alternative end bent substructure types should be considered on a case-by-case basis.

Piles

Integral abutment bridges depend on the flexibility of the piles to accommodate longitudinal bridge movements. Utilizing the prescribed bridge lengths above and detailing piles as suggested below will limit the need to analyze and design the piles to resist forces developed from longitudinal movements of the integral abutment. In addition, integral abutment piles should not be less than 10 ft. in length.

For sites with rock, dense material, or cohesive soils, provide prebored holes as necessary to allow for adequate pile lengths. After the piles are installed and fixity is achieved, the prebored hole shall be filled with loose dry sand. In addition, integral abutments shall be designed with a single row of vertical piles oriented such that longitudinal bridge movements shall induce bending about the weak axis, i.e. the pile strong axis shall be parallel to the bridge control line (workline). If bending stresses are excessive, then the piles may be oriented for bending about the strong axis.

Approach Slabs and Wing Walls

Approach slabs shall be supported on a blockout provided in the end bent integral diaphragm, and shall be anchored to the diaphragm so that it moves longitudinally in concert with the bridge.

The roadway end of the approach slab shall be supported on a sleeper slab. Use BAS11 -- "Bridge Approach Slab for Integral Abutment" for preparing plans. Brace piles for wing walls piles are not permitted. Wing walls may be tapered to reduce their resistance to longitudinal bridge movements.

Figures 6-119, 6-120, 6-121, 6-122 and 6-123 show details at the integral end bent for steel girder and concrete girder superstructures.

7-3 End Bents

General

See Figures 7-3, 7-4, 7-5, 7-6 and 7-8 for the end bent cap layout on tangent alignments. These figures should be modified for use on curved or spiral alignments. For cored slab superstructures, use an expansion joint material thickness of 1½ inch (38 mm) in lieu of the 1 inch (25 mm) shown in the above Figures.

All end bent caps shall be sloped on the top surfaces of the cap. See Figure 7-9 for details to include on the plans.

For bridges on a moderate to heavy skew (skew ≤ 60° or 120°≤ skew), chamfer cap and wing corners in accordance with Figure 7-10.

Temporary drainage details shall be shown on the plans for all end bents. For details and notes to be shown on the plans, see Figure 7-11. The figure is drawn to show normal crown and should be modified for superelevated structures or other conditions on a project specific basis.

Backwalls

A backwall shall be use on all bridges except cored slab bridges with approach slabs. See Figure 7-12 for backwall details. For deep superstructures, backwalls shall be designed on a project specific basis.

Provide a horizontal construction joint between the backwall and the end bent cap. Extend the construction joint through the wings level with the cap. Run the 'K' bars the entire length of the backwall from wing to wing. Match the 'H' bars in the wing to the 'K' bars in the backwall as applicable. See Figures 7-13 and 7-14 for details.

The elevations on the top of the backwall along the fill face side shall be shown on the plans. Elevations shall be shown at the left side, at the centerline of survey or the grade point, and at the right side. Additional elevations at all crown breaks shall also be indicated on the plans.

When applicable, detail oversized blockouts for water or sewer utilities passing through the backwall. A blockout sized 4” (100 mm) larger than the utility pipe diameter is to be used with all utility lines. Place the following note on the plans:

> ***Center utility in blockout and fill annular space around utility pipe with joint filler in accordance with Standard Specification Article 1028-1.***

Turned Back Wings

In general, turned back wings shall be detailed for all end bents.

For bridges over highways and railroads, the wings shall be of a sufficient length to provide a 1'-0" (300 mm) minimum berm 1'-6" (450 mm) above the bottom of the end bent cap as shown in Figure 7-15. For bridges over streams, the wings shall be of a sufficient length to provide berm widths as indicated in Figures 11-1 11-2 and 11-3. In no case shall the wing length be less than 2 feet (600 mm) as measured from the fill face. When the length of the wing exceeds 11 feet (3.35 m), detail a brace pile located one-third ($^1/_3$) of the length from the end. See Figure 7-16.

The wings shall be placed at the outside edge of the backwall. The outside edge of the wings shall be located 3 feet (1 m) measured perpendicular from the outside edge of superstructure and shall be parallel to the superstructure. Insure that the wings and cap are adequately reinforced at this junction. For details of wings, see Figure 7-13.

In general, the tops of the wings should follow the grade line. See Figure 7-14 for a suggested method of detailing sloped wings. For bridges with metal rails, set the top of the wings at the outside edge of the approach slab to match the top of the curb or sidewalk. For bridges with concrete barrier rail, the top of the wings at the outside edge of the approach slab should be set level with the top of the approach slab. Detail the bottom of the wings as level or follow the grade using the same criteria for sloping the top of the wings.

The turned back wings shall have a blockout as shown in Figures 7-17 and 7-18. This blockout allows for slip forming of the parapet. Reinforcing steel in the blockout may be bent as necessary. The blockout concrete shall be placed after the concrete barrier rail or parapet and end post are cast.

Use a 1 inch (25 mm) expansion joint material in the vertical joint between the backwall and the approach slab. See Figure 7-14 for details.

When the Foundation Recommendations call for Reinforced Bridge Approach Fill, place the following note on the end bent sheet:

> ***The Contractor shall provide for installation of the 4" (102 mm) ϕ drain pipe through the wing wall as required for Reinforced Bridge Approach Fills, see the Roadway plans. Reinforcing steel in the wing wall may be shifted as necessary to clear the drain pipe.***

Special Wings

Any wings other than the turned back wings outlined above shall be considered special wings and should only be used when site or design conditions prevent the use of turned back wings. Such conditions may include matching existing wings, tying to an existing structure, a very shallow superstructure, etc. Where special wings are necessary, the Project Engineer shall submit the proposed special wing design and layout to the Engineering Development group.

7-4 Pile Bents

General

Unless otherwise specified, the criteria of this section shall apply to both interior pile bents and pile supported end bents.

Pile bents shall be designed as per the AASHTO LRFD Bridge Design Specifications. Buckling due to the unsupported length of the pile should be checked. See Section 7-6.

The minimum amount of embedment for pile heads shall be as indicated in Section 2-1. For sloped caps, the minimum pile embedment shall be detailed from the bottom of the cap at the controlling edge to the top of the pile. A minimum 9 inch (230 mm) clear distance shall be maintained from the exterior pile to the end of cap. For details of pile end bents and interior pile bents, see Figures 7-23, 7-24, 7-25, 7-26, 7-27 and 7-28.

Caps

Minimum Width

Type of Pile	Cap Width	
	Single Row	Double Row
HP 10x42 (HP 250x26), HP 12x53 (HP 310x79) or 12 inch (305 mm) prestressed concrete	2'-9" (840 mm)	4'-0" (1.22 m)
HP 14x73 (HP 360x108) steel	3'-0" (910 mm)	4'-3" (1.30 m)
16 inch (406 mm) prestressed concrete or 18 inch (457mm) steel pipe pile	3'-3" (990 mm)	5'-0" (1.52 m)
20 inch (508 mm) prestressed concrete	3'-8" (1.12 m)	5'-8" (1.73 m)
24 inch (610 mm) prestressed concrete or steel pipe pile	4'-2" (1.27 m)	
30 in (760mm) steel pipe pile	5'-0" (1.52 m)	

Smaller widths may be used for bents with a single row of piles without brace piles; however, reinforcing steel clearance should be checked.

Minimum Depth

Type of Pile	Cap Depth
Single row pile system	2'-6" (760 mm)
Double row pile system	3'-0" (910 mm)

Other Reinforcement

Place 4 or 5 - #4 (#13) 'B' bars longitudinally at equal spaces above each row of piles and #4 (#13) 'B' bars at 4' (1.2 m) ± centers placed normal to the cap.

Provide 2 - #4 (#13) circular 'S' hoops around each pile in a single row system and 3 pairs of #4 (#13) rectangular 'S' bars around each pile in a double row system. See Figures 7-23, 7-24, 7-25, 7-26, 7-27 and 7-28.

For interior bents, provide a #9 (#29) 'U' shaped bar in each end of the cap as detailed in Figure 7-28.

7-5 Post and Beam Bents

Caps

The minimum cap size shall be 3'-2" (970 mm) wide by 2'-6" (760 mm) deep for use with 3'-0" (914 mm) ϕ columns. In general, the cap width shall be a minimum of 2 inches (50 mm) wider than the column diameter.

When using drilled piers, the cap width shall be a minimum of 8 inches (200 mm) wider than the column diameter. When the drilled pier extends to the bottom of the cap, the minimum cap width shall be 8 inches (200 mm) wider than the drilled pier diameter.

Use hammerhead or other non-standard bent types on special instructions. Use round noses on hammerhead piers in stream crossings to reduce drift problems.

Columns

When circumstances dictate the use of spread footings, design the column for 1 m (3'-0") of extra height.

In Seismic Performance Zone 2, column connections shall be detailed with #4 (#13) or #5 (#16) ties at 3" (75 mm) centers for a minimum of one-half the column diameter into the cap and footings. Use #4 (#13) ties for 4'-0" (1220 mm) diameters or smaller and #5 (#16) ties for 4'-6" (1372 mm) diameters and larger. See Figure 7-29.

Minimum Diameter

The minimum size column shall be 3'-0" (914 mm) ϕ. Standard column sizes include 3'-0" (914 mm), 3'-6" (1066 mm), 4'-0" (1220 mm), 4'-6" (1372 mm) and 5'-0" (1524 mm). For column diameters greater than 5'-0" (1524 mm), increase the column diameter in 6 inch (152.4 mm, rounded to the nearest even millimeter) increments.

Spacing

In general, the column spacing should not exceed approximately 20 feet (6 m) center to center of columns. The overhang from the end of the cap to the face of the column should not be greater than 4 feet (1.2 m) and not less than 3 feet (915 mm). Preferably this dimension should be between 3'-3" (1.0 m) and 3'-9" (1.15 m).

In order to minimize the number of drilled piers, consideration shall be given to increasing the center to center spacing of the columns and overhang dimension to achieve a reasonable cap design.

Reinforcing Steel

Columns are to be designed in accordance with the AASHTO LRFD Bridge Design Specifications. Do not detail any bar smaller than a #9 (#29) for 'M' and 'V' bars.

Spiral column reinforcing steel, to be used on all round columns, shall be W20 or D-20 cold drawn wire or a #4 (#13) plain or deformed bar with a pitch of 3 inches (75 mm). The splice of the spiral column reinforcement should be lapped 2 feet (610 mm). For spiral reinforcement details, see Figure 7-30.

Place the following note, completed with the applicable spiral designation (SP1, SP2, etc.), directly beneath or near the Bill of Material for each applicable bent. Place a double asterisk (**) in the size column for spiral reinforcing steel in the Bill of Material.

***** The ___ _ spiral reinforcing steel shall be W20 or D-20 cold drawn wire or #4 (#13) plain or deformed bar.***

When epoxy coated spiral column reinforcing steel is required in columns, include a quantity and pay item for "Epoxy Coated Spiral Column Reinforcing Steel".

Batter

For bents of major coastal structures, the exterior columns shall be battered 6% in the lateral direction when the ratio of the height of the column to the center to center distance of the exterior columns is greater than 1.0.

Construction Joints

In general, construction joints shall be used at the top of the footing and the bottom of the cap. A permitted construction joint shall be shown at approximately mid-height for columns 20 feet (6 m) or more in height.

7-6 Piles

General

The capacity to which piles are to be driven, as recommended by the Geotechnical Engineering Unit , shall be indicated on the General Drawing. Where pile loads for various bents on a structure are computed to require different capacities, group the bents together and call for the maximum capacity required if the loads are within 4 - 5 tons (35 - 45 kN) of each other rather than calling for several different capacities on one structure.

For fender system piles, place the following note on the plan sheet showing the top of pile and pile tip elevations:

> ***The Contractor shall determine the pile length such that the final top and tip elevations will be as indicated.***

Piles shall not be designated with a pile length in instances where the Contractor is responsible for determining the pile lengths.

When indicated on the Foundation Recommendations, the Contractor shall have the option to use 12 inch (305 mm) prestressed concrete piles with steel pile tips in lieu of HP steel piles. For the note to be placed on the General Drawing, see Section 5-2 "Piles".

When indicated on the Foundation Recommendations, the Contractor shall have the option to use HP 12x53 (HP 310x79) steel piles in lieu of 12 inch (305 mm) prestressed concrete piles with steel pile tips. For the note to be placed on the General Drawing, see Section 5-2 "Piles".

When HP 10x42 (HP 250x62) steel piles are used, the Contractor shall have the option to use HP 12x53 (HP 310x79) steel piles. For the note to be placed on the General Drawing, see Section 5-2 "Piles".

Design Loads

For preliminary design of end bents, use the design load values shown in the table below. The compressive resistance shown is for piles that are entirely embedded in the ground

Pile Type	P_r, Compressive Resistance (w/ Pile Tip) (kips)	P_r, Compressive Resistance (w/o Pile Tip) (kips)
HP 10x42	310	370
HP 12x53	385	465
HP 14x73	535	640
14" SPP	635	740
16" SPP	730	850
18" SPP	825	960
24" SPP	1105	1290
30" SPP	1390	1620
12" PCP		
16" PCP		
20" PCP		
24" PCP		

Brace Piles

Brace piles shall be used in all end bents where the distance from the crown of roadway to the natural ground line exceeds 10 feet (3 m). Consideration shall also be given to using brace piles where little pile penetration is anticipated, mucky conditions exist and for other special conditions which might warrant their use.

The spacing of brace piles shall not exceed 25 feet (8 m) center to center.

For single and double row of piles, see Figures 7-23 and 7-24 for end bent details and Figures 7-26 and 7-27 for interior bent brace piles details.

For end bents, batter brace piles 3 inches per foot (250 mm per 1000 mm). For interior bents, batter brace piles 1 ½ inches per foot (125 mm per 1000 mm).

Pile Spacings and Clearances

For minimum pile embedment, see Section 2-1.

For end bents, the pile maximum spacing shall be 10'-0".

Use a minimum of five piles in end bent and interior pile bents.

Both brace and vertical piles shall be spaced uniformly about the cap centerline.

Steel Piles

The standard splice detail should be placed on at least one bent drawing for each bridge on which HP steel piles are used. Reference should be made to this detail on the plans for all other bents in which HP steel piles are used. See Figure 7-31.

When steel piles are used in pile bents on grade separations, encase the piles with a square concrete jacket from the bottom of the cap to 3'-0" (920 mm) below the proposed ground line. The jackets for HP 12x53 (HP 310x79 piles) shall be 1'-8" (510 mm) by 1'-8" (510 mm). The jackets for HP 14x73 (HP 360x108) piles shall be 1'-10" (560 mm) by 1'-10" (560 mm). All jackets shall be reinforced with wire mesh.

Steel pipe piles shall be used in accordance with the standard drawings. When pipe piles are used in pile bents on grade separations, the depth of the concrete plug shall extend a minimum of 5'-0" (1.5 m) below the top of the pile. When pipe piles are used in end bents or pile footings, the embedment length of the pile into the footing shall be filled with concrete as detailed in Figure 7-25.

When steel piles are used at Corrosive Sites, see Section 12-13 "Painted Steel".

Exposed steel piles over streams or railroads shall be galvanized. Place the following note on the plans:

> ***The steel piles shall be galvanized in accordance with Section 1076 of the Standard Specifications.***

Prestressed Concrete Piles

Prestressed concrete piles shall be in accordance with the standard drawings for Prestressed Concrete Piles. When prestressing cables are to be released by burning, the cables shall be burned in opposite pairs and follow the pattern shown on the Standards.

When prestressed concrete piles are used at Corrosive Sites, see Section 12-13 “Corrosion Protection Measures”.

When the Contractor is allowed to substitute HP 12x53 (HP 310x79) steel piles in lieu of 12 inch (305 mm) prestressed concrete piles, the substructure should be designed as though the concrete piles will be used. Add the necessary details to the plans to cover both steel and concrete piles. The pay item shall be for “12 inch (305 mm) Prestressed Concrete Piles”.

When the Foundation Recommendations require steel pile tips for prestressed concrete piles, see Section 5-2 “Piles” for the plan note to be placed on the General Drawing. For 20 inch (508 mm) prestressed concrete piles that require the use of steel pile tips, add the pile tip details as shown in Figure 7-32 to the Standard PCP2.

Composite Piles

When the Foundation Recommendations require prestressed concrete piles composite with steel piles, a steel pile splicer shall be used to connect the steel pile tip to the driven steel pile. See Figure 7-33. Place the following notes on the plans:

For Steel Pile Splicer, See Special Provisions
For Steel Pile Tips, See Special Provisions

7-7 Footings

General

The minimum footing thickness in Seismic Performance Zone 1 is 2'-0" (610 mm) without piles and 2'-9" (840 mm) with piles. Seismic Performance Zone 2 requires an increased footing thickness. The top of footings shall have 1'-6" (460 mm) minimum earth cover.

Provide minimum reinforcement consisting of #6 (#19) bars at 1'-0" (300 mm) centers located 2 inches (50 mm) clear from the top of the footing. In single column bents, use #6 (#19) bars at 1'-0" (300 mm) centers or 50% of the area of bottom reinforcement, whichever is greater. These bars are to be used in both the transverse and longitudinal directions.

For stream crossings, study each pier location to determine the elevations of the pier footings that might pose hazards to navigation. Specify on the plans a maximum top of footing elevation if deemed necessary.

Stream Crossings

The Foundation Recommendations will consider the scour potential of the site for stream crossings. Subsurface and hydraulic investigations will be made to determine the probable depth of scour or floatation of material. Foundation and structural analysis will determine the required lateral support of the pile. The bottom of footing and pile tip elevations should be determined such that scour will not endanger the structure.

The Soils and Foundations Section will provide bottom of footing elevations and scour critical elevations for all stream crossing structures. For notes to be placed on the plans, see Section 5-2 "Footings".

The Soils and Foundations Section will determine when footings shall be protected against scour. For details to be shown on the plans, see Figures 7-34. 7-35 and 7-36. Place the following note on the plans:

> ***No separate payment will be made for pier scour protection. The entire cost of same shall be included in the lump sum price for "Foundation Excavation."***

Spread Footings

The minimum length for spread footings shall be 20% of the overall distance from the bottom of the footing to the crown of the roadway, rounded up to the next 6 inches (150 mm).

The splice length for spread footing 'M' bars shall be detailed 3 feet (1 m) longer than required to accommodate possible adjustments in the footing elevation.

Pile Footings

The minimum distance centerline to centerline of exterior piles for each pile footing shall be 15% of the overall distance from the bottom of the footing to the crown of the roadway, rounded up to the next 3 inches (75 mm).

For minimum pile embedment, see Section 2-1.

The minimum center-to-center spacing for piles shall be the larger of 2'-6" (760 mm) for steel, or 2'-9" (840 mm) for concrete, and 2.5 pile diameters/widths. The distance from the edge of any pile to the nearest face of the pile footing shall not be less than 9 inches (230 mm).

When concrete piles with steel pile tips are offered as an option to steel piles in the footing, the footing shall be designed based on the minimum spacing for concrete piles.

A minimum of four piles shall be used in each footing. If fewer than six piles are used, all piles shall be vertical. If six or more piles are used per footing, brace piles shall be used in accordance with the detail for foundation piles in bents. See Figure 7-37.

When foundation piles are used with laterally battered columns, detail a strut between the footings.

Pile Caps

For pile or drilled pier caps supporting post and beam or hammerhead type substructures, use the following criteria to set the bottom of cap elevation:

- At Corrosive Sites subject to tidal fluctuations, set the bottom of the cap at the mean low tide elevation.
- For constructability in river crossings, set the bottom of the cap 1 foot (300 mm) above the normal water surface elevation.

Foundation Excavation

Foundation excavation for all spread and pile footings shall be paid for on a lump sum basis.

For post and beam end bent substructures, specify the measurement and payment for foundation excavation on a cubic yard (cubic meter) basis. For computing the plan quantity, see Figure 7-38.

The benefits of designing a seal for interior bents vary. As a general guideline, seals shall be used when the water depth is 20 feet (6 m) or more. Foundation seals shall be detailed to provide 2 feet (610 mm) minimum clearance from each side of the footing to the edge of the foundation seal. If there is any doubt regarding the use of a seal, the Project Engineer should consult with Soils and Foundation, Hydraulics and Construction personnel for their recommendations. When a seal is required, the following note should be shown on the plans:

> ***Cofferdams shall not be dewatered when the water elevation is above El.__________ .***

Complete the note with the water elevation to which the seal depth is designed.

7-8 Drilled Piers

General

Drilled piers shall be terminated 1 foot (300 mm) ± above the normal water surface elevation for shafts located in water and 1 foot (300 mm) ± below the ground line for grade separations, railroad overheads, or piers located in the banks of streams. Always provide a construction joint at the drilled pier termination and proceed with a column into the cap. When there is insufficient distance to detail a lap splice between the top of the drilled pier and the bottom of the cap, use a column with the same diameter as the drilled pier.

The payment for drilled piers shall be on the basis of length per linear foot (meter) of "______ Dia. Drilled Piers Not in Soil" and "______ Dia. Drilled Piers in Soil". Geotechnical Engineering Unit will provide the breakdowns for these quantities to be shown on the plans. Provide a separate quantity for the "Drilled Pier Concrete" in the concrete breakdown. All reinforcing steel in the drilled pier shall be included in the pay items for "Reinforcing Steel" and "Spiral Column Reinforcing Steel" or "Epoxy Coated Spiral Column Reinforcing Steel".

When instructed by the Geotechnical Engineering Unit, permanent casing for drilled piers shall be provided. The payment shall be on the basis of length per linear foot (meter) of "Permanent Steel Casing for ______ Dia. Drilled Pier". The Foundation Recommendations will provide the bottom of casing elevation to be used for computing the pay length for the permanent steel casing. Detail the casing termination at the construction joint between the drilled pier and the column and use this elevation as the top elevation when computing the pay length. The Foundation Recommendations will also provide notes to be placed on the plans.

When instructed by the Geotechnical Engineering Unit, a special pay item for "SID Inspection" will be required and paid for per each. For all projects using drilled piers, pay items for "Crosshole Sonic Logging" and "CSL Tubes" shall be included and paid for per each and per linear foot (meter), respectively.

Reinforcement

Longitudinal reinforcement shall be as required by design. Detail a lap splice at the construction joint when sufficient distance is available between the construction joint and the bent cap. Always detail the longitudinal steel with 3 feet (1 m) of extra length.

When there is insufficient distance to detail a lap splice between the top of the drilled pier and the bottom of the cap, detail the drilled pier reinforcing steel to extend 3 feet (1 m) above the construction joint. Detail column reinforcing steel from 2 feet (700 mm) above the construction joint to the proper embedment in the cap. Maintain constant bar size and spacing between the column and the drilled pier. Detail the couplers to be staggered as shown in Figure 7-39.

Spiral reinforcement shall be detailed as W31 or D-31 cold drawn wire or a #5 (#16) plain or deformed bar with a 5 inch (125 mm) pitch and 4 inches (100 mm) minimum clearance to the spiral. At the construction joint between the drilled pier and the column, detail a spiral splice and provide a standard size and pitch spiral in the column. Do not detail the spiral with the 3 feet (1 m) of extra length.

Notes Place the following notes on the plans where applicable:

For Drilled Piers, see Special Provisions.

The Contractor's attention is called to the fact that the longitudinal reinforcement for the drilled piers is detailed with 3 feet *(one meter)* ***of extra length.***

All steel in the drilled piers is included in the pay items for "Reinforcing Steel" and "Spiral Column Reinforcing Steel" or "Epoxy Coated Spiral Column Reinforcing Steel".

Place the following note, completed with the applicable spiral designation (SP1, SP2, etc.), directly beneath or near the Bill of Material for each applicable bent. Place a double asterisk (**) in the size column for spiral reinforcing steel in the Bill of Material.

***** The ___ _ spiral reinforcing steel shall be W31 or D-31 cold drawn wire or #5*** *(#16)* ***plain or deformed bar.***

When there is not room to detail a lap splice in the longitudinal steel,

Splicing of the longitudinal bars in the drilled pier will not be permitted.

Mechanical couplers shall be used to join the longitudinal drilled pier reinforcing steel to the column reinforcing steel. The height of the couplers shall be staggered on alternating bars by 1 foot *(300 mm)* ***and the drilled pier and column steel shall be cut accordingly. See Special Provisions for Mechanical Butt Splicing for Reinforcing Steel.***

For grade separations, railroad overheads, or shafts located in banks of streams,

The location of the construction joint in the drilled piers is based on an approximate ground line elevation. If the construction joint is above the actual ground elevation, the Contractor shall place the construction joint 1 foot *(300 mm)* ***below the ground line.***

When a pay item for permanent steel casing is required by the Foundation Recommendations,

For permanent steel casing, see Special Provision for Drilled Piers.

7-9 Abutments

MSE Walls When mechanically stabilized earth structures are used as walls or abutment supports (e.g., reinforced earth, retained earth, tiedback wall, Hilfiker, etc.), see Section 12-14.

7-10 Rock Embankment

Generally, the Hydraulics Unit will recommend rock embankment when the proposed fill is to be constructed within the limits of a lake or stream. Rock embankment is used to reduce the siltation of lakes and streams and provides a stable embankment resistant to scouring. The Hydraulics Unit will furnish the following information:

- Water surface elevations
- Elevation and limits of proposed rock embankment
- Proposed core for bridge piles
- Typical section of rock embankment

When requesting the Foundation Recommendations, the Project Engineer shall advise the Geotechnical Engineering Unit that rock embankment will be required.

The proposed rock embankment, core material and elevation of rock embankment shall be shown in the plan and section views of the General Drawing, with a note to see the Roadway plans. For the note to be placed on the General Drawing, see Section 5-2 “General”.

The Project Engineer shall check with the Roadway Design Engineer to verify that the Roadway plans contain the required details and pay items for “Rock Embankment” and “Core Material” for the structure.

7-11 Pier Crashwalls for Railroad Overheads

Piers supporting bridges over railways and located within 25 feet (7.62 m) of the centerline of a railroad track are required by AREMA Specifications to be protected by a reinforced concrete crashwall. The top of the crashwall shall be located at least 6 feet (1.83 m) above the top of the higher rail for CSX Railroad and 10 feet (3.05 m) for Norfolk Southern Railroad.

Crashwalls adjacent to Norfolk Southern rails shall be a minimum of 2'-6" (760 mm) thick. For CSX rails, the adjacent crashwall thickness shall match the column diameter but shall not be less than 2'-6" (760 mm). For multi-column bents, a crashwall shall connect the columns and extend at least 2'-6" (760 mm) beyond the exterior columns. These extensions shall be measured parallel to the track. When a pier consists of a single column, the crashwall shall extend for a minimum distance of 6 feet (1.83 m) from both sides of the column. The face of all crashwalls shall extend a minimum distance of 6 inches (150 mm) beyond the face of the column on the side nearest to the track and shall be anchored to the column and footings with adequate steel reinforcement. The crashwall shall extend to at least 4 feet (1.2 m) below the surrounding grade. For general crashwall details, see Figure 7-40.

Where a crashwall is used, show a permitted construction joint at the top of the crashwall. Splice the 'V' bars at the permitted construction joint for crashwalls. If a construction joint is required in the cap, a construction joint should be detailed at a comparable position in the crashwall.

7-12 Median Pier Protection

Guardrail shall be placed in those medians containing piers less than 30 feet (9.14 m) from the edge of pavement and the pier columns shall be protected with a concrete barrier. Special consideration shall be given when barrier shape protection is justified. When barrier shaped protection is required, use Class A concrete reinforced similarly to the barrier rail used on the bridge deck. "Reinforcing Steel" and "Class A Concrete" quantities are included in the bent Bill of Material. No separate pay item is required. See Figure 7-41 for details.

If the pier offset is between 30 feet (9.14 m) and 40 feet (12.19 m), then an earth berm shall be placed. When such berms are used, the pier footing shall be designed accordingly and the slope protection placed according to the applicable standard. The top of the footing shall be located 1'-6" (460 mm) below the theoretical ditch line.

Piers with an offset over 40 feet (12.19 m) require no impact protection.

There are several different end treatments for median pier protection, such as attachments for impact attenuators, steel guardrail or concrete median barriers. When median pier protection is called for on the Structure Recommendations, the Structure Design Unit must work closely with the Roadway Design Unit during the plan development stage.

CHAPTER 8
REHABILITATION

8 -1 General

This chapter provides guidance for the design of bridge widenings and rehabilitations.

In determining the scope of the rehabilitation work, representatives from the Structure Design Unit, the Bridge Maintenance Unit, and the Division Bridge Maintenance Unit should be involved. In addition, coordination with the various units will be required to reserve the equipment necessary to inspect the entire bridge.

When existing and proposed centerlines are not coincident, show both centerlines and the distance between them.

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8 -2 Superstructure

When widening a bridge, do not mix steel beams or girders with prestressed concrete girders in the same span.

The feasibility of using lightweight concrete shall be investigated for deck rehabilitation projects. For the unit weight of lightweight concrete, see Section 2-3 of this manual.

Consideration shall be given to using link slab details for deck replacement projects on simple span superstructures in lieu of replacing the joints.

For full deck replacements on prestressed concrete girder superstructures, place the following note on the plans:

> ***Prior to deck removal, the Contractor shall submit to the Engineer the proposed method for removing concrete in the areas directly above the prestressed girders.***

When an existing bridge is to be widened, call for a full depth saw cut to be made in the existing slab where the slab is to be removed. Locate the saw cut to clear the edge of the flange and detail adhesively anchored dowels in the same horizontal plane as the top mat of reinforcing steel. Place the following note on the plans:

> ***A full depth saw cut shall be made and existing concrete removed in accordance with plan details.***

For bridge widening projects, epoxy coated reinforcing steel shall be used in the proposed section of the bridge. When latex modified concrete is used, do not use epoxy coated reinforcing steel.

The Traffic Control, Pavement Marking, and Delineation Section of the Traffic Congestion and Engineering Operations Unit (Traffic Control) may require a temporary bridge rail. The pay item for temporary bridge rail will be a Traffic Control item and a Roadway detail or standard. Close coordination between Structure Design, Roadway Design and Traffic Control is extremely important. For guidelines on the use of temporary barrier rail, see Section 6-2 "Bridge Rails".

On the existing deck, detail the same joint type as that used on the new deck. Place the following note on the plans:

> ***During the joint installation procedure, the joint and surrounding area shall be kept clean and free of debris.***

When one or two girders are used to widen prestressed concrete girder bridges, the existing diaphragm tie rod should be extended for use in the new diaphragm. A turn-buckle or sleeve nut shall be used for this extension. For details of this tie rod assembly, see Figure 8-1. When three or more girders are added, do not detail a connecting diaphragm.

For bridge widenings, it is preferable to detail a 4 foot (1.2 m) or 5 foot (1.5 m) bay between new and existing beams or girders and eliminate the bent diaphragms. For beam or girder spacings wider than 5 foot (1.5 m) and for intermediate diaphragms, detail a bolted angle connection between existing steel beams or girders and new diaphragms and place the following note on the plans:

> ***Where diaphragms are to be bolted to existing steel beams, do not remove paint from the contact surface.***

The diaphragm shall be field welded to the angle. The other end of this diaphragm is to be bolted to a shop welded connector plate with vertical slots. The connector plate slots should be sized so as to permit the vertical dead load deflection of the proposed adjoining beam. Show washers as required by the AASHTO Standard Specifications. Place the following note on the plans:

> ***Connection bolts are to be located at the bottom of the connection slots and tightened to snug fit prior to field welding opposite end of diaphragm. After welding diaphragm to connection angle and prior to the pouring of the slab, back off bolts ½ turn to allow for vertical deflection of new beam. After deflections have occurred, tighten bolts as required by the Standard Specifications.***

Rolled beams shall be designed with cover plates only for those widening projects in which the existing structure contains cover-plated beams. Cover plates to be welded to flange members should be at least 1 ½ inches (40 mm) and preferably

2 inches (50 mm) less in width than the member to which it is welded. Plates should be welded with a continuous fillet weld. The thickness of the cover plate should be between 5/16 inch (8 mm) and twice the flange thickness. Cover plates shall extend the length of the beam and terminate 1 foot (300 mm) from the centerline of bearing, see Figure 8-2. The weld shall be designed per the AASHTO LRFD Bridge Design Specifications. The appropriate minimum fillet weld sizes are defined in the ANSI/AASHTO/AWS D1.5 "Bridge Welding Code".

When widening existing structures, the rotational and deflection characteristics of the existing bearing type should be considered when selecting the new bearings.

For rehabilitation and widening projects detailed with elastomeric bearings, detail a field weld between the sole plates and the flanges at both ends of the new beams or girders. Place the following note on the plans:

> ***When field welding the sole plate to the girder flange, use temperature indicating wax pens, or other suitable means to ensure that the temperature of the sole plate does not exceed 300°F*** *(149°C)*. ***Temperatures above this may damage the elastomer.***

Approach pavement brackets are to be used only when bridges with existing pavement brackets are to be widened.

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8 -3 Substructure

At an end bent where a curtain wall is used, the top surface area of the cap shall be given the protective coating except that the Contractor may, but is not required to, coat the top surface area to be covered by the curtain wall.

When anchor bolt removal is required, the pay item should be per each bolt in lieu of a lump sum basis.

CHAPTER 9
REINFORCED CONCRETE BOX CULVERTS

9-1 General

The culvert design begins when the Structure Design Unit receives the Culvert Survey and Hydraulic Design Report from the Hydraulics Unit. This report in conjunction with the Roadway plans shall be used to compute the culvert length, design fill, and other items that lead to the completed culvert plans.

Culverts shall be detailed as cast-in-place according to the information provided in the Culvert Standards. For all cast-in-place culverts regardless of location, the option to construct a Precast Box Culvert in lieu of the cast-in-place culvert shown on the plans is permitted except where limited by maximum design fill. The Precast Box Culvert option shall not be allowed if the maximum design fill over the culvert exceeds 10 ft (3m) in Divisions 1-4, 6, 8 and 15 ft (4.5m) in Divisions 5,7, and 9-14. However, the Division Office has the final decision on whether to allow the Precast Box option, even if these requirements are met. Therefore, when attending the Preliminary Field Inspection inquire if the Precast Box option should be allowed. A note allowing the option has been provided on the culvert barrel standard drawings, so if the option is disallowed for any reason the note must be removed. For cast-in-place culverts, the designer is not responsible for the design of the precast option, but should include the Special Provision for Optional Precast Reinforced Concrete Box Culverts if the aforementioned criteria are satisfied.

When a precast box culvert is recommended for a project, the plans should be prepared according to supplied information and the PBC Culvert Standard.

Culverts without floor slabs (three-sided culverts including con-span type structures) will be used when recommended by the Hydraulics Unit. Typically, this situation occurs when there is a high rock line (within 3-5 feet of the ground surface) to allow footings to be keyed into rock.

9-2 Culvert Length and Design Fill

Culvert lengths shall be computed for each culvert end from the centerline of roadway to the control point. The length for each end of the culvert shall be first computed as measured normal to the centerline of the roadway and shall be comprised of three components. The first distance is from the centerline of the roadway to the edge of the roadway shoulder. The second component is the horizontal distance from the edge of the shoulder to the point where the fill slope intersects an elevation 9 inches (230 mm) above the top of culvert top slab. The final dimension is 1'-3" (380 mm) representing the culvert headwall thickness.

The sum of these three dimensions is then skewed as necessary and rounded to the nearest inch (20 mm). The overall length of the culvert on the plans shall be the sum of the computed lengths for the two ends.

Figure 9-1 is a worksheet that may be used as an aid in computing culvert lengths and design fill. A computer program is also available for this purpose.

For cast-in-place culverts, compute the design fill by first locating the point of maximum fill and determining its elevation. Then compute the bed elevation below this point. Add the vertical clearance to the bed elevation to get the elevation at bottom of the top slab. Subtract the bottom of top slab elevation from the elevation of the point of maximum fill to arrive at the design fill.

For precast box culverts, the design earth cover shall be reported as the elevation difference between the point of maximum fill and the top of the top slab.

Subsurface investigations shall be requested from the Geotechnical Engineering Unit for all box culverts with a design fill of 50 feet (15.25 m) or more and for other box culverts deemed necessary by the Engineer. These culverts may need to be constructed with camber. Request the camber information from the Geotechnical Engineering Unit. See Section 9-4 “Special Notes and Details” for the required plan note. The camber shall not exceed one half the fall from the inlet of the culvert to its outlet.

9-3 Design

Cast-in-place culvert barrels shall be designed by using the Load Factor Design Method. Culvert wing standard drawings are available and shall be used in conjunction with the culvert barrel standard drawings.

Footings must be designed for culverts without floor slabs.

The acute corners of all multiple barrel culverts outside the skew range of 45° to 135° with more than 7 feet (2.1 m) of vertical clearance shall be strengthened with a counterfort. Office standard drawings are available and shall be used in assembling culvert plans meeting the above described conditions.

For culverts with a sloped and/or tapered inlet, see the example of Figures 9-2 and 9-3.

For excessively thick culvert slabs, use a Standee bar when the clear distance between the bottom mat of transverse steel and the top mat of longitudinal steel exceeds 15 inches (380 mm). Detail the Standee bar in accordance with the CRSI “Manual of Standard Practice”.

9-4 Assembly of Culvert Standards

General

Culvert barrel and wing standard drawings have been prepared and should be used
in conjunction with the barrel section cell tutorial when preparing plans for cast-in-place culverts. When appropriate, the partial plan view of the Culvert barrel standards shall be modified to reflect the use of tapered outlet wings. Show the splice length chart from the computer printout on the plans. Culvert Standard PBC shall be used when precast box culverts are required for a project.

Cast-In-Place Culverts

General

For example plans for a single box culvert, see Figures 9-4, 9-5 and 9-6.

Cast-in-place culverts shall be paid on a cubic yard (cubic meter) basis for "Class A Concrete" and in lbs (kg) of "Reinforcing Steel".

Location Sketch

The following items should be included:

- Location sketch oriented on the plan sheet so that the centerline of the roadway is vertical with stations increasing from the bottom to the top of the sketch.
- Line designation (-L-, -Y-, etc.)
- North arrow
- Existing structures, roads, buildings, and drainage pipes shown with a dashed line. Show existing wood lines, stream outlines, and other terrain features.
- Proposed culvert outline shown as a solid line
- Skew angle
- Name of stream
- Flow direction of stream
- Destination arrows on road
- Centerline station of culvert
- Roadway grade point elevations at the centerline of culvert, bed elevation of culvert beneath the reference station, and roadway fill slopes. This information should be placed at the bottom of the location sketch in the following manner:

  Grade Point Elev. @ Station ______= ____________
  Bed Elev. @ Station______ = ____________
  Roadway Slopes ______:1
- Top of the footing elevation for culverts without floor slabs only.

Hydraulic Data

The following information, attained from the Culvert Survey and Hydraulic Design Report, shall be shown near the location sketch.

- Design Discharge
- Frequency of Design Flood
- Design High Water Elevation
- Drainage Area
- Basic Discharge (Q100)
- Basic High Water Elevation

In addition to the above data, show the Overtopping Flood Data for all Federal Aid bridges and for other bridges when data is provided.

Overtopping Flood Data
Overtopping Discharge
Frequency of Overtopping Flood
Overtopping Flood Elevation

In case Overtopping Flood Data is not required, the Hydraulics Unit will provide a note to that effect on the Bridge Survey and Hydraulic Design Report. This note should be placed on the plans.

The high water elevation shown in the Culvert Survey Report applies to the inlet end of the culvert. Since this is based on the estimated length of culvert as shown in the Culvert Survey Report sketch, rather than the final computed length, adjustments should be made to the high water elevation based on the actual length shown on the plans. This adjusted elevation should be shown to the nearest tenth of a foot (hundredth of a meter).

Adjustment in the high water elevation can be made as a direct variation of the grade of stream bed as indicated in the Culvert Survey Report. Thus, if the upstream end of a box culvert on a 1.2% grade is 8'-4" (2540 mm) longer than the Culvert Survey Report shows, the high-water elevation should be raised 0.1 feet (30 mm). If this change in elevation adjustment is greater than 0.1 feet (30 mm), contact the Hydraulics Unit for their review and approval.

Section of Barrel

The barrel section shall be shown on the plans. For single barrel culverts with a vertical clearance of 8 feet (2.54 m) or less, detail continuous high chair uppers (CHCU) in the top slab to support the corner 'A' bars.

Bench Mark

Show the bench mark description and its elevation in or adjacent to the location sketch for all culvert plans.

'C' Bars in Barrel

The actual number of 'C' bars shall be shown in the barrel section. Add the following note near the barrel section:

There are _____ 'C' bars in section of barrel.

Centerline Profile

Show the centerline profile on the plans. The Hydraulics Unit should include the profile in the Culvert Survey and Hydraulic Design Report. If more details are required, contact the Hydraulics Unit.

Weep Hole Location

The dimension from the bed elevation to the weep hole shall be shown on the "Culvert Section Normal to Roadway" detail for all culverts. To compute this dimension, find the difference between the normal flow line and the centerline bed elevation, as shown on the Culvert Survey Report, add 6 inches (150 mm) and then round to the next ½ inch (10 mm).

Construction Joints for Cast-In-Place Culverts

Bottom Slab of Multiple Barrel Culverts

Call for a permitted construction joint in the bottom slab of all multiple barrel culverts 12 inches (300 mm) from an interior wall and place the following note on the plans:

Steel in the bottom slab may be spliced at the permitted construction joint at the Contractor's option. Extra weight of steel due to the splices will be paid for by the Contractor.

For culverts constructed in stages, detail a construction joint in the bottom slab consistent with the staging plans proposed by the Roadside Environmental and Hydraulics Units.

Bottom of Fillets

For culverts with a vertical clearance of 4 feet (1.2 m) or less, no construction joint shall be permitted at the bottom of fillets and the following notation with an arrow to the bottom of fillets should be shown on the plans in the "Section of Barrel":

No construction joint permitted.

For culverts with a vertical clearance greater than 4 feet (1.2 m) through 8 feet (2.4 m), a construction joint at the bottom fillets is optional and the following notation with an arrow to the bottom of fillets should be shown on the plans in the "Section of Barrel":

Permitted Construction Joint

For culverts with a vertical clearance of 9 ft (2.7 m) or greater, a construction joint is required at the bottom of fillets and the following notation with an arrow to the bottom of fillets should be shown on the plans in the "Section of Barrel":

Construction Joint

If necessary, modify the notes on the culvert barrel standard drawings.

Transverse Joints In Barrel

Transverse construction joints shall be used in culverts exceeding 70 feet (21 m) in length. These joints shall be parallel to the main slab steel. Reinforcing steel shall not be cut or spaced to fit the joints. Where transverse construction joints are required, show a typical joint on the plans with a reference to the following note:

Transverse construction joints shall be used in the barrel, spaced to limit the pours to a maximum of 70 feet *(21.0 m)****. Location of joints shall be subject to approval of the Engineer.***

Culvert Extensions

For culvert extensions, the wall thickness shall be a minimum of 8 inches (205 mm).

When extending culverts, detail #6 (#19) dowels at 1'-6" (450 mm) centers for the top and bottom slabs and exterior walls. See Figure 9-7. Place the following notes on the plans:

Dowels shall be used to connect the culvert extension to the existing culvert as shown. For note regarding setting of dowels, see Sheet SN *(Sheet SNSM)****.***

If approved by the Engineer, the Contractor may use the existing wings as temporary shoring for the construction of the culvert extensions. In this case, the bottom slab of the extension shall be poured at least 72 hours prior to cutting the wings. The wings may be cut earlier provided the slab concrete strength has reached a minimum compressive strength of 1500 psi *(10.3 MPa)****.***

Precast Box Culverts

General

A precast box culvert shall be detailed when recommended by the Hydraulics Unit or the Division Office and may be used in other situations. When the planning report requires a Precast Box Culvert to satisfy staging and time requirements, a cast-in-place culvert option shall still be designed and detailed in the plans. In this occurrence, place the following note on the plans:

> ***The Contractor may choose to construct a cast-in-place culvert in accordance with the included plans at no additional cost to the department. The contract requirements with respect to construction staging and time shall be satisfied regardless of whether a precast or cast-in-place culvert is constructed.***

Precast box culverts shall not be detailed for use as a pedestrian underpass. If the precast option was available, remove the standard note allowing the precast option and replace it with the following note:

> ***No precast reinforced box culvert option will be allowed.***

When a precast reinforced concrete box culvert is called for on the plans, the Contractor will submit the design. Detail only the size and length of the culvert, the number of boxes, the cast-in-place headwall, the cast-in-place wings, and the guardrail attachment, if required. Do not detail slab thickness, wall thickness, or barrel reinforcement other than the 'D' bars that dowel into the cast-in-place headwall and curtain wall. When determining the length of the culvert, assume both the wall and slab thickness to be one-twelfth of the horizontal clear span of one barrel, but do not detail it as such.

See "Turned Back Wing Standards" of this section for the use of wing standard drawings with precast box culverts.

For example of precast box culvert, see Figures 9-8, 9-9 and 9-10.

Precast box culverts shall be paid for on a lump sum basis for "Precast Reinforced Concrete Box Culvert at Station ____________".

Location Sketch

The information provided for a precast box culvert shall be the same as that provided for the cast-in-place culverts.

Section of Barrel

The barrel section shall be shown on the PCB Culvert Standard.

Bench Mark

Show the bench mark description and its elevation in or adjacent to the location sketch for all precast box culvert plans.

Centerline Profile

Show the centerline profile on the plans. The Hydraulics Unit should include the profile in the Culvert Survey Report. If more details are required, contact the Hydraulics Unit.

Weep Hole Location

The determination of weep hole locations shall be as described for cast-in-place culverts. The dimension from the bed elevation to the weep hole shall be shown in the elevation view of the "Typical Precast Unit" detail.

Plan Details

Complete or include the following items on the PBC Culvert Standard:

- Typical Section - Show the width and height of the box.
- Elevation - Show the length of the culvert
- Standard Notes - Enter the design earth cover.
- Plan View - Delete the view that is not applicable to the project.
- Bill of Material and Bar Schedule
- Skewed Precast Box Culverts - Select the appropriate detail from Figure 9-11.

Detail a 3 inch (75 mm) space between lines of multiple precast box culverts.

For multiple barrel precast box culverts, place the following note on the plans:

One permitted construction joint will be allowed in the end curtain wall.

Precast Three-Sided Culverts

Use a three-sided precast culvert when indicated on the Hydraulic Survey Report. When a precast three-sided culvert is called for on the plans, the Contractor will submit the design for the barrel section, foundation, and cast-in-place wing walls and headwalls. Detail the plans showing both the arch and flat-top shaped sections unless otherwise indicated. Detail the size (opening), length, and number of cells. For the purpose of calculating culvert length, assume the slab thickness to be one-twelfth of the horizontal clear span, but do not detail on the plans. Include foundation design parameters and notes provided by the Soils and Foundations Unit in the plans.

Turned Back Wing Standards

Turned back wing standard drawings have been prepared using 2:1 wing slopes. For unusual skew conditions, see Figures 9-12 and 9-13 for wing layout details.

A 1 inch (25 mm) expansion joint shall be provided in the wings of all cast-in-place culverts. The wing standard drawings incorporate this expansion joint. A strip of filter fabric shall be placed on the fill face side of the wing along this expansion joint to prevent the migration of fine material through the joint. Place the following note on the plans:

> ***A 3 foot** (900 mm) **strip of filter fabric shall be attached to the fill face of the wing covering the entire length of the expansion joint.***

For an example of the wing standard drawing, see Figure 9-10.

For precast box culverts, the wing standard drawings shall be modified as follows:

- The 1 inch (25 mm) expansion joint material shall be provided at the junction of the wing and the precast end unit, rather than in the wing.
- For wings on skewed precast box culverts, place the following note on the wing standard drawing:

  > ***If the option of 90° skewed ends of the precast box is used, dimensions marked with an asterisk will need adjustment.***

When this note is used, an asterisk shall be placed on the dimensions locating the intersection of the wing and curtain wall footings and the start of the wing slope.

For an example of a wing for a precast box culvert, see Figure 9-10.

Tapered Outlet Wings

Typically, outlet wings for reinforced concrete box culverts and culvert extensions shall be tapered extensions of the exterior barrel walls. Do not use tapered outlet wings in conjunction with bottomless culverts or when the Hydraulics Unit requires standard turned back wings. For barrel heights greater than 10 feet (3.0 m) or skews outside the range of 45° to 135°, design outlet wings on a case by case basis. Do not use tapered outlet wings when a low flow channel is included in the culvert design.

The slope of the wing shall match the roadway fill slope along the skew. A concrete apron shall extend the bottom slab of the barrel and connect the outlet wings. The thickness of the apron shall match the thickness of the bottom slab of the barrel. Details for the tapered outlet wings are provided in Figures 9-14 through 9-15.

The length of the wing shall be determined by extending the outlet wing until it intersects a plane 1'-6" (460 mm) above the apron. Adjust the wing length to the nearest inch (20 mm). Provide weepholes in the outlet wings as necessary to continue the weephole spacing from the barrel.

Detail #6 (#19) dowel bars and #4 (#13) horizontal bars to extend the pattern of 'C' bars from the exterior barrel walls. Continue the spacing of the 'C' bars and 'A' bars in the barrel throughout the apron. The vertical leg of the 'A2' bars shall be modified at the end of the apron to provide adequate clearance to the top of the wing. The 'V' bars in the wings shall match the spacing of the 'A2' bars in the apron. Detail a curtain wall at the end of the apron. The size of the 'S' bars in the curtain wall shall match that of the 'S' bars in the headwall.

Unless otherwise dictated by the Hydraulics Unit, provide filter fabric and Class I rip rap within the limits of Figure 9-16. Include the entire area of the concrete apron and tapered wings in the calculation of required foundation conditioning material. Include in the Total Structure Quantities two special culvert pay items for "Filter Fabric for Drainage" in square yards (square meters) and "Plain Rip Rap, Class I (2'-0" thick) (600 mm thick)" in tons (metric tons).

Place the following note on the plans:

> ***At the Contractor's option the vertical construction joint between the outlet wings and the barrel may be eliminated and the 'C' bars in the barrel may be extended to replace the 'D' and 'H' bars in the wings and slab.***

Culvert Excavation

Culvert excavation shall be computed in accordance with Figure 9-17 and included as a lump sum item on the plans, estimates and proposals for box culverts with floor slabs. Culvert excavation for box culverts with floor slabs shall be shown on a lump sum basis for "Culvert Excavation, Station ______" in the estimate and on the plans.

For precast culverts, calculate culvert excavation based on a wall and slab thickness equal to 10% of the horizontal clear span of one barrel.

For those culverts that require the removal of unsuitable material, the limits of the culvert excavation shall include the undercut excavation.

For culverts without a floor slab, the excavation for the footing shall be computed and listed in the Bill of Material as "Foundation Excavation" instead of "Culvert Excavation".

Unsuitable Material

When the bottom of the culvert is above the limits of unsuitable material, show the following notes on the culvert plans:

> ***No work shall be done on the culvert at Sta. _________ until the area of the box culvert has been undercut to Elev. ____ and unsuitable material replaced with suitable material, properly compacted to the elevation of the bottom of the proposed floor slab. The limits of this undercut excavation shall be at least the limits of the box culvert including the wings. No separate payment will be made for any temporary sheeting, undercut, or unsuitable material replacement as required to construct the proposed culvert. Payment is included in the lump sum price for Culvert Excavation.***

Foundation Conditioning Material

For all box culvert foundations, use a 12 inch (300 mm) blanket of Foundation Conditioning Material under the entire area of the floor slab. Do not compute a quantity for standard turned back wings. Use a weight of 1.904 tons/yd^3 (2.26 metric tons/m^3) for this material. This material shall be included in the Bill of Material on a ton (metric ton) basis for "Foundation Conditioning Material, Box Culvert" and rounded to the nearest ton.

When calculating a quantity of foundation conditioning material for precast culverts, assume a wall thickness equal to 10% of the horizontal clear span of one barrel.

Low Flow Channels

When the Culvert Survey and Hydraulic Design Report calls for a low flow channel, the plans shall be detailed to show a plan view of the culvert specifying sill locations as determined by the Culvert Survey and Hydraulic Design Report. The height of the sill at the entrance of the other barrel(s), bed material, and maximum stone size shall be as dictated by the Culvert Survey and Hydraulics Design Report. The bed material shall be labeled in the plan view drawing and the following note shall be placed on the plans:

> ***Bed material placed between sills in the culvert shall provide a continuous low flow channel between the lower sills. The material shall be natural stone with a gradation size similar to that of Class __ Rip Rap. Stones larger than ___ inches*** *(mm)* ***shall not be placed within the low flow channel. Bed material is subject to approval by the Engineer.***

The quantity of rip rap, in tons (metric tons), shall be listed in the Total Quantities section of the culvert plan sheets. When preparing an estimate, include the rip rap as a special culvert pay item for "Plain Rip Rap, Class ___".

See Figure 9-18 for typical culvert sill details.

Special Notes and Details

Assumed Live Load = HS20 *(MS18)* ***or Alternate Loading.***

For culvert diversion details and pay item, see Erosion Control Plans.

For all metric projects,

All dimensions are in millimeters unless otherwise noted.

All elevations are in meters.

Show the TIP number, county and the culvert identification station in the spaces over the title block. Show the Federal Aid Project Number (if applicable) in the upper right hand corner of the first sheet for each culvert.

For Federal Aid projects,

The Contractor shall provide independent assurance samples of reinforcing steel as follows: For projects requiring up to 400 tons *(360,000 kg)* ***of reinforcing steel, one 30 inch*** *(760 mm)* ***sample of each size bar used, and for projects requiring over 400 tons*** *(360,000 kg)* ***of reinforcing steel, two 30 inch*** *(760 mm)* ***samples of each size bar used. The bars from which the samples are taken must then be spliced with replacement bars of the size and length of the sample, plus a minimum lap splice of thirty bar diameters.***

For major culverts, those defined as having a total interior opening of 20 ft (6 m) or greater measured along the centerline of roadway, use the following above the title block:

Bridge No._____

If a culvert is replacing an existing bridge, the following note must be placed over the title block:

Replaces Bridge No. ______.

One of the following notes should also be placed on the plans:

(After serving as a temporary structure) ***the existing structure consisting of*** *(number, length and type of spans; clear roadway width and type of floor)* ***on*** *(type of substructure)* ***and located*** *(distance up or downstream from proposed structure)* ***shall be removed. The existing bridge is presently posted below the legal load limit. Should the structural integrity of the bridge further deteriorate, this load limitation may be reduced as found necessary during the life of the project.*** (When a special circumstance exists warranting a Special Provision, add to the note: ***See Special Provision for __________.****)*

(After serving as a temporary structure) ***the existing structure consisting of*** *(number, length and type of spans; clear roadway width and type of floor)* ***on*** *(type of substructure)* ***and located*** *(distance up or downstream from proposed structure)* ***shall be removed. The existing bridge is presently not posted for***

load limit. Should the structural integrity of the bridge deteriorate during construction of the proposed structure, a load limit may be posted and may be reduced as found necessary during the life of the project. (When a special circumstance exists warranting a Special Provision, add to the note: ***See Special Provision for __________.)***

Where an opening is required in the top slab for a catch basin, provide for 4 inch (100 mm) corner fillets and call for the steel in the opening to be cut and bent up if the catch basin is reinforced. Provide extra bars to reinforce the opening if required.

Where it is necessary to provide for pipes through the sidewalls of culverts, the reinforcing steel shall be bent around the pipe and the area reinforced with additional bars. Place the following note on the plans:

The _______ ϕ pipe through the sidewall of the culvert shall be located by the Engineer. The reinforcing steel shall be field bent as necessary to clear pipe.

If possible, do not locate pipes through culvert walls or wing walls. If it is necessary to run the pipe into the culvert, consider carrying it through the top slab by way of a junction box. Another alternate would be to construct a junction box adjacent to the culvert so that a length of pipe may be run perpendicularly into the culvert wall.

If scour is prevalent, rip rap may be used in the front of the culvert wing. This recommendation will be provided on the Culvert Survey and Hydraulics Design Report. Detail rip rap, if used, approximately 3 feet (900 mm) above the wing footing.

The headwall skew angle on arch culverts shall not exceed 20° regardless of the culvert skew.

When preparing the plans for arch culverts or box culverts with a top slab thickness of 18 inches (455 mm) or greater, place the following note on the first culvert sheet:

Detailed drawings for falsework and forms for this __________ shall be submitted. See Sheet SN *(Sheet SNSM)*.

When the Geotechnical Engineering Unit provides a required camber, place the note on the plans:

The reinforced concrete box culvert shall be constructed with ____ inches *(mm)* ***of camber to account for anticipated settlement.***

Guardrail Anchor Assemblies

Provisions for anchoring guardrail to RCBC slabs shall be made when the fill above the top slab at the location of the guardrail posts is less than 3.5 feet (1.070 m). However, if the skewed width of the culvert (including walls) is less than 23'-8" (7.21 m), use an alternative guardrail design with a guardrail post spacing of up to 25'-0" (7.62 m). See Roadway Standard Drawing 862.01 sheet 9 of 11. This method eliminates the need for anchoring guardrail to the culvert. The Project Engineer must coordinate with the Roadway Design Unit to ensure the Roadway plans are properly detailed.

See Standard GRA1 and Figure 9-19 for guardrail anchorage details. For guardrail anchor assemblies on precast box culverts, see Figure 9-20. Guardrail anchor assembly details shall be included in the plans for attachment of guardrail to RCBC slabs.

The guardrail anchor assemblies shall be spaced at 6'-3" (1.905 m) centers.

See the Roadway Standards for details of the guardrail, post and post base plate.

The Roadway Design Unit shall be furnished with the guardrail anchor assembly spacings used on each RCBC.

CHAPTER 10
REINFORCING STEEL

10-1 General

Design details of reinforcing steel, unless otherwise modified herein, shall comply with the requirements of the AASHTO Standard Specifications. When detailing reinforcing steel, consideration should be exercised to keep the number of bends in a bar to a minimum, to eliminate hooks if possible, and to use as few different bars as possible. It is important to note that the bar count for any structural element shall be shown in only one view and only the bar mark called out in other views.

10-2 Bar Sizes

All reinforcing steel shall be deformed bars. Use the bar number on all drawings to indicate bar sizes as follows:

Bar Size Designation	Nominal Diameter	Approximate Diameter Outside Deformations
#3 (#10)	3/8" (9.5 mm)	7/16" (11.1 mm)
#4 (#13)	1/2" (12.7 mm)	9/16" (14.3 mm)
#5 (#16)	5/8" (15.9 mm)	11/16" (17.5 mm)
#6 (#19)	3/4" (19.1 mm)	7/8" (22.2 mm)
#7 (#22)	7/8" (22.2 mm)	1" (25.4 mm)
#8 (#25)	1" (25.4 mm)	1 1/8" (28.6 mm)
#9 (#29)	1 1/8" (28.7 mm)	1 1/4" (31.8 mm)
#10 (#32)	1 1/4" (32.3 mm)	1 7/16" (36.5 mm)
#11 (#36)	1 7/16" (35.8 mm)	1 5/8" (41.3 mm)
#14 (#43)	1 11/16" (43.0 mm)	1 7/8" (47.6 mm)
#18 (#57)	2 1/4" (57.3 mm)	2 1/2" (63.5 mm)

For additional bar properties and steel areas, see Figures 10-1 and 10-2.

10-3 Placing Steel

Detailing

Indicate the reinforcing steel in concrete sections with a single broken line. When dimensioning reinforcing bars from concrete surfaces, show clear dimensions. Show the dimensions between reinforcing bars as center to center. The center to center distance between parallel bars is measured perpendicular to the longitudinal axis of the bars.

Provide reinforcement for shrinkage and temperature stresses near the exposed surfaces of walls and slabs otherwise unreinforced. Space this reinforcement at a maximum of 18 inches (450 mm).

For cast-in-place concrete, the clear distance between parallel bars shall not be less than 1.5 times the nominal diameter of the bars, 1.5 times the maximum size of the coarse aggregate, or 1½ inches (38 mm).

In detailing the ‘A’ bars in bridge decks, show on the plans the dimension from the work points to the first full length ‘A’ bars. Place the top mat ‘A’ bars directly above the bottom mat ‘A’ bars. Do not stagger these transverse bars.

When spacing the top longitudinal bars in a bent cap, avoid interference with the anchor bolts and the 4 inches (102 mm) ϕ pipes.

Bar Supports

Bar supports are required in a number of locations on bridges. In general, it will be necessary to provide supports for reinforcing steel in deck slabs and overhangs, railings, bent diaphragms, intermediate diaphragms, bent caps, approach slabs and culvert slabs. It is not necessary to detail bar supports in the backwalls, parapets, sidewalks, footings, or vertical walls of culverts.

Figures are included throughout this manual as a general guide to detail these bar supports. Use the outside bar deformations, in lieu of nominal bar diameters, in setting clear dimensions and the heights of bar supports. For outside bar deformations, see Section 10-2. Detail a definitive spacing for bar supports rather than a “maximum” spacing. Bar support heights shall be detailed to the nearest ¼ inch increment and shown to the nearest ¼ inch (1 mm).

Show the location and height of beam bolsters in deck slab overhangs as shown in Figures 6-20 and 6-22. The beam bolsters shall be located 1 foot (300 mm) from the outside edge of superstructure. When prestressed concrete panels are used, two bar supports shall be shown in the slab overhangs.

The type of supports used should be standardized as much as possible. References for detailing bar supports include the CRSI “Manual of Standard Practice” and literature distributed by the manufacturers.

Concrete Cover

The following table shall be used to determine the minimum cover to main reinforcement, unless stated otherwise, for various structure elements:

Structure Element	Cover	
	All Other Sites	Corrosive Sites
Bridge Deck to top of slab to bottom of slab	 2 ½" (65 mm) 1 ¼" (32 mm)	 2 ½" (65 mm) 1 ¼"(32 mm)*
Footings and Pile Caps to top face to all other faces	 2" (50 mm) 3" (75 mm)	 4" (100 mm) 4" (100 mm)
Bent Caps to bottom of cap to ends of cap to top of cap (stirrups) to sides of cap (stirrups)	 3" (75 mm) 2" (50 mm) 2" (50 mm) 2" (50 mm)	 4" (100 mm) 3" (75 mm) 3" (75 mm) 3" (75 mm)
Columns (spiral)	2" (50 mm)	3" (75 mm)
Drilled Piers (spiral)	5" (125 mm)**	6" (150 mm)**
Culverts to bottom of bottom slabs and footings to all other faces	 3" (75 mm) 2" (50 mm)	 3" (75 mm) 2" (50 mm)
Approach Slabs	2" (50 mm)	2" (50 mm)

* When using removable forms, cover shall be increased to 2 ½ inches (65 mm).

** In the event the drilled pier extends into a bent cap or pile cap, the cover may be reduced to 4 inches (100 mm).

For structures at Corrosive Sites, refer to Section 12-13.

Basic Development and Splice Lengths

For bars in tension, bar splices and development lengths should be in accordance with Figures 10-3 and 10-4.

For bars in compression, the bar splice and development length should be in accordance with Figure 10-5.

For superstructures, show the splice length chart of Figure 10-6 on the plans.

For a guide to substructure splice length and the required embedment of 'V' bars into the cap, see Figures 10-7 and 10-8. Show the splice length for bars in the substructure units on the plans at each splice.

For reinforced concrete box culverts, obtain the splice length chart from the Culvert Design computer program and include on the plans.

10-4 Detailing Reinforcing Bars

Bill of Material

The bar schedules and types should be enclosed in a Bill of Material as shown in Figure 10-9. The Superstructure Bill of Material shall have a breakdown of reinforcing steel for each span or continuous unit. Do not repeat deck reinforcing bar designations in different spans unless the bars are identical in size, length and shape.

Bar nomenclature shall remain the same as that already in use rather than as recommended in the ACI Manual.

Bar Schedule

All reinforcing bars should be listed in the Bar Schedule in the following manner:

Bar	No.	Size	Type	Length	Weight

Weights shall be shown to the nearest lb (kg). Programs are available that will compute the bar weights and list the results in a format suitable for inclusion in the plans. For example, see Figure 10-9.

Bar Bending Diagrams

Bar bending diagrams and details shall be made in accordance with the recommendations of the ACI "Manual of Standard Practice for Detailing Reinforced Concrete Structures".

Bar bending details should be to the nearest ¼ inch (5 mm) and bar lengths should be shown to the nearest inch (20 mm). The dimensions for bent bars shall be out-to-out dimensions and noted as such in the bending diagram, see Figure 10-10. The bending diagrams shall be titled "Bar Types" in the plans.

Particular attention is called to the standard hook details in the above listed manual and as shown in Figure 10-11. Reinforcing bars shall be provided with hooks as required by design.

Maximum Bar Lengths

The maximum length shall be 30 feet (9 m) for #3 (#10) and #4 (#13) bars and 60 feet (18 m) for all other bar sizes. For ease of shipping, avoid detailing only one or two bars in a bridge 60 feet (18 m) long while the other bars are much shorter.

10-5 Epoxy Coated Reinforcing Steel

As a minimum corrosion protection measure, all reinforcing steel in sidewalks, barrier rails, and concrete medians shall be epoxy coated. In addition, the top mat of steel for all bridge decks and approach slabs, and the stirrups and longitudinal reinforcing steel in the end diaphragms shall be epoxy coated.

At Corrosive Sites, as defined by Figures 12-29 and 12-30, the reinforcing steel, bar supports, and incidental steel for all cast-in-place concrete elements shall be epoxy coated.

For precast and cast-in-place culverts east of the Corrosive (blue) line of Figure 12-29, all reinforcing steel and bar supports shall be epoxy coated. For the note regarding bar supports and incidental steel, see Section 12-12 “Corrosion Protection”.

For bridge widening projects, epoxy coated reinforcing steel shall be used in the proposed section of the bridge. When latex modified concrete is used, do not use epoxy coated reinforcing steel.

CHAPTER 11
BRIDGE LAYOUT

11-1 General

Structure lengths, widths, and clearances shall be in agreement with the State of North Carolina, Department of Transportation, Division of Highways, Bridge Policy. Also, refer to the Structure Recommendations and the Policy and Procedure Manual.

In general, end bent slopes shall be 1½:1 in fill sections and 2:1 in cut and partial cut sections unless recommended otherwise by the Geotechnical Engineering Unit. In Divisions 1, 2 and 3, consult with the Geotechnical Engineering Unit for the recommended end bent slopes prior to laying out the bridge.

11-2 Stream Crossings

The minimum grade on a structure shall be 0.2%. Any proposed grade less than 0.2% shall be discussed with the Roadway Design Unit.

The minimum clearance between the bottom of the beams or girders and the design high water elevation shown on the Bridge Survey Report should be 2 feet (600 mm) for all interstate and arterial roads and 1 foot (300 mm) for all other roads.

If practical, skewed bridges on horizontal curves with a repetitious span arrangement should have all bent worklines set at a constant skew angle at their point of intersection with the curve.

Slopes shall be normal to the end bent cap. Final consideration of the rate of slope and slope protection will depend upon the Hydraulic Design.

The Hydraulics Unit computes the span lengths based on the details of Figures 11-1, 11-2 and 11-3. In general, a 1 foot (300 mm) minimum earth berm shall be used.

Changes to grade, span arrangement or superstructure type that would affect the waterway opening beneath the structure should not be made without first obtaining approval from the Hydraulics Unit.

11-3 Grade Separations

End bent slopes should be normal to the ditch beneath the structure unless specific conditions dictate otherwise. A 1 foot (300 mm) wide berm 1'-6" (450 mm) above the bottom of cap shall be provided. In a combination cut and fill slope, a 3 foot (1.0 m) berm normal to the cut slope should be provided at the toe of the fill. This berm is not required when slope protection is used and/or where 2:1 slopes are used. See Figure 11-4 for berm details.

When slope protection is used, the berm shall be sloped away from and normal to the cap at a rate of ½ in/ft (50 mm/m). The proper berm width should be used in determining the length of bridges. The berm widths should be computed for both ends of both end bents. These berm widths and elevations should be shown on the General Drawing and on the slope protection standard drawings.

The toe of the slope should intersect the centerline of the ditch shown on the Structure Recommendations.

Consult with the Roadway Design Unit when the vertical clearance does not meet the requirements as provided in the Structure Recommendations and the NCDOT Bridge Policy.

11-4 Railroad Overheads

Structures over railroads must provide horizontal clearances that meet the approval of the applicable railway company and shall be in conformity with the Federal Aid Policy Guide. Figure 11-5 shall be used to set the bridge length for both CSX and Norfolk Southern Railroads. These clearances may be changed to reflect individual site conditions as requested by the railroad, provided they meet the criteria outlined in the Policy Guide. The Policy and Procedure Manual should be used as a guide in laying out the structure prior to submission to the railway company for their approval. All span arrangements over Railroad tracks should be reviewed and approved by the Assistant Bridge Design Engineer for Railroad Coordination. In general, horizontal clearance for the use of off track equipment should be provided on one side of the track.

Consult with the Roadway Design Unit when the vertical clearance does not meet the requirements as provided in the Structure Recommendations and the NCDOT Bridge Policy.

In fill sections, end bent slopes should be normal to the end bent cap, and in cut and partial cut sections, slopes should be normal to the railway ditch. The location of the toe of the slope should conform to the Federal Aid Policy Guide.

A minimum berm of 1 foot (300 mm) width normal to the end bent cap and 1'-6" (450 mm) above the bottom of the end bent cap shall be provided in front of the end bents.

Unless otherwise specified by the Railroad, slope protection shall be used for railroad overheads.

When slope protection is used, the berm shall be sloped away from and normal to the cap at a rate of ½ in/ft (50 mm/m). The proper berm width shall be used in determining the length of bridges. The berm widths shall be computed for both ends of both end bents. These berm widths and elevations shall be shown on the General Drawing and on the slope protection standard drawings.

In order to eliminate railroad shoring, drilled piers shall be used for the foundation of post and beam bents adjacent to railways.

Crashwalls should be considered in accordance with Section 7-10 of this manual.

11-5 Bridges on Horizontal Curve

The following information shall be included in the superstructure and approach slab drawings for horizontally curved bridges:

- Dimensions along the bent control line from the workline to each gutterline.
- Arc offset dimensions for the outside edge of superstructure for each span. These chord-to-arc ordinates shall be at 5 foot (1.5 m) intervals about the span's midpoint.
- Arc offset dimensions for longitudinal construction joints, if applicable.
- Short chord at the centerline survey for each span with the chord length and the intersection angle between the chord and the centerline of joint.

A long chord layout should be shown on the General Drawing. See Section 5-1 "Long Chord Layout" in this manual.

11-6 Pedestrian Bridges

Structures for pedestrian traffic shall meet the criteria set forth by the AASHTO Guide Specifications for Design of Pedestrian Bridges.

For submission of plans to FHWA where required, refer to the Policy and Procedure Manual.

CHAPTER 12
MISCELLANEOUS

12-1 Bridge Approach Slabs

General

Approach slabs are required on all bridges. The following ten standard drawings are available and should be used in plan development:

- BAS1 - "Bridge Approach Slab for Rigid Pavement"
- BAS2 - "Bridge Approach Slab for Rigid Pavement with Barrier Rail"
- BAS3 - "Bridge Approach Slab Details for Rigid Pavement with Barrier Rail"
- BAS4 - "Bridge Approach Slab for Flexible Pavement"
- BAS5 - "Bridge Approach Slab for Flexible Pavement with Barrier Rail"
- BAS6 - "Bridge Approach Slab Details for Flexible Pavement with Barrier Rail"
- BAS7 - "Bridge Approach Slab for Prestressed Concrete Cored Slab"
- BAS8 - "Bridge Approach Slab for Prestressed Concrete Cored Slab with Barrier Rail"
- BAS9 - "Bridge Approach Slab Details for Prestressed Concrete Cored Slab with Barrier Rail"
- BAS10 - "Bridge Approach Slab Details"
- BAS 11- "Bridge Approach Slab Details for Integral Abutments"

The appropriate BAS Standards to use are dependent upon the type of approach pavement, superstructure, and bridge rail. Standards BAS1, BAS4, or BAS7 should be used when a one or two bar metal rail is on the bridge. When the bridge is detailed for a concrete barrier rail, use BAS2 with BAS3, BAS5 with BAS6, or BAS8 with BAS9. Standard BAS10 should always be used in conjunction with the other BAS Standards. BAS7, BAS8 and BAS9 are reserved for use with cored slab bridges. BAS11 is for Integral Abutments.

Figures 12-1, 12-2, 12-3, 12-4, 12-5, 12-6, 12-7, 12-8, 12-9, 12-10, 12-11. 12-12, 12-13, 12-14, 12-15, 12-16 and 12-17show examples of the use of the approach slab standard drawings and several plan views to be included therein.

Approach slabs shall be paid for on a lump sum basis. Approach slabs that do not contain an asphalt overlay shall be grooved to the same limits as the deck.

Full Width Approach Slabs

General

Bridges located on NHS routes and/or carrying a design year ADT greater than 5,000 shall have a 25'-0" (7.62m) approach slab. Otherwise specify a 15'-0" (4.57m) approach slab. Use Figure 12-18 for selecting the appropriate length of approach slab. All approach slabs shall be constructed with a minimum depth of 1'-0" (305mm).

For flexible approach pavements detail both ends of the approach slab parallel to the end bent fill face. The approach slab length shall be measured along the workline.

For rigid approach pavements detail the roadway end of the approach slab perpendicular to the centerline of the roadway. The minimum length shall be measured along the shortest edge. On very wide bridges and/or bridges with a heavy skew, the long edge of the approach slab may become excessive. For such cases limit the length of the longer edge of the approach slab to 50'-0" (15.24m). This may be accomplished by stepping in the approach slab at approach pavement lane lines while maintaining the minimum dimension.

Approach slab reinforcing bars shall be sized and spaced as follows:

Bar	Size	Spacing
A1	#4 (#13)	1'-0" (300mm)
A2	#4 (#13)	1'-0" (300mm)
B1	#5 (#16)	6" (150mm)
B2	#6 (#19)	6" (150mm)

Guidelines for placement of reinforcing steel are as follows:

- 'B' bars shall be placed parallel to the alignment or the chord formed between the beginning (end) of the approach slab and the end bent work point
- 'A' bars shall be placed parallel to the skew
- For approach slabs without parallel ends, orient the 'A' bars to minimize the number of cut bars

Approach slabs should be detailed individually for dual bridges.

On dual lane highways where one wide bridge is used in lieu of separate bridges, four approach slabs are required using the full width approach slab concept. On the median side, extend the approach slab to the edge of the approach paved shoulder. Detail the approach slab on the median side to be consistent with the Roadway plans.

Show the horizontal arc offsets for the left and right edges of approach slabs on a horizontal curve.

Reinforcing Steel Details

Reinforcing steel shall have 2 inch (50 mm) minimum clearance in the top and bottom of the slab.

Reinforced Bridge Approach Fills

Reinforced bridge approach fills shall be detailed on the plans unless directed otherwise by the Foundation Recommendations. The "Reinforced Bridge Approach Fill" is a Roadway pay item.

Construction Elevations

Construction elevations for approach slabs shall be computed for the left edge, centerline, right edge and along all crown breaks between the gutter lines. See Figures 12-19 and 12-20 for the "Construction Elevation Layout for Approach Slab". See Section 6-2 "Construction Elevations" for additional information.

Guard Rail Attachment to Barrier Rails

Guardrail attachment to the bridge barrier rails shall satisfy the requirements of NCHRP Report 350. The Roadway Design Unit will recommend the type of guardrail anchor unit (GRAU) and the location of guardrail attachments on the Structure Recommendations or the Roadway plans. Typically the guardrail will be attached to the bridge at all four corners of the bridge. However, the trailing ends of dual structures in the median may not require guardrail if certain conditions are met.

Typically, the Type B-77 GRAU will be specified. The B-77 GRAU attaches to the New Jersey barrier rail on the bridge. Use Standard GRA2 – "Guardrail Anchorage for Barrier Rail" to show the anchor assembly details on the structure plans. See Figures 12-1, 12-2 and 12-3.

If no guardrail attachment is specified, do not detail an anchor assembly at that location.

The approach slab width shall equal the superstructure gutterline-to-gutterline plus 8" (200mm) on each side to accommodate the triangular curb.

When a flat-faced concrete rail, such as the 1, 2 or 3 Bar Metal Rail, is used on the bridge, then typically the Type III GRAU will be specified. For this type of rail, the Type III GRAU attaches to the flat-faced rail on the bridge. Use the applicable Standards BMR1-8.

Barrier Rail Transitions

When a Type III GRAU is specified for use on a bridge with a New Jersey barrier rail, detail the concrete barrier rail transition to provide a vertical face for guardrail attachment. The barrier rail transition shall be supported on the approach slab. See Figures 12-4 and 12-5.

The approach slab width shall equal the out-to-out superstructure width to accommodate the barrier rail transition.

The barrier rail shall transition from a concrete barrier rail shape to a vertical parapet over the length of the approach slab. The barrier rail transition consists of a 3 foot (915 mm) long vertical parapet, a 5 foot (1.525 m) transition section, and a concrete barrier rail. The length of the concrete barrier rail shall vary depending on the approach slab length and skew conditions. The end of the approach slab shall be squared off where it intersects the rail.

For cored slab structures and cast in place deck bridges, the concrete barrier rail width shall be 1'-6" (457 mm). The width of vertical parapet shall be not less than 9" (240 mm) when it is not protected from traffic impact by guardrail.

Barrier rail transition details are shown on BAS3, BAS6, BAS9, and Figure 12-7. Include the concrete and reinforcing steel quantities for the barrier rail transition in the Approach Slab Bill of Material as shown in Figures 12-4.

The Type III GRAU shall be attached 1'-10" (560 mm) from the end of the barrier rail transition. Show the location of the anchor assemblies for the guardrail attachment on Standard BAS3, BAS6, or BAS9. See Figure 12-5. If no guardrail attachment is specified, provide the barrier rail transition on the approach slab but do not detail an anchor assembly at that location.

Curbs

The approach slab width shall be full width from gutterline to gutterline plus 8 inches (200 mm) on each side for the curb on bridges with one or two bar metal rail. Details of the curb on the approach slab are shown on the BAS1, BAS4, and BAS7 and in Figures 12-1 and 12-2.

Sidewalks

When a three bar metal rail with sidewalk is used on the bridge, continue the sidewalk onto the approach slab. The approach slab width shall extend 5'-0" (1.5 m) or 5'-6" (1.65 m) from the gutterline to accommodate each sidewalk. Modify the BAS Standards as necessary. See Figures 12-16 and 12-17 for additional sidewalk details to include on the plans.

12-2 Title Sheet Procedures

Title Sheet Furnished by Roadway Design Unit

When the structures are part of a project that includes roadway work, a reproducible copy of the title sheet may be obtained from the Roadway Design Unit. Replace the Roadway Design Project Engineer's and Project Design Engineer's names with those of the Structure Design Unit's Project Engineer and Project Design Engineer.

Title Sheet Drawn by Structure Design Unit

When the project does not include roadway work, the title sheet shall be developed by the Structure Design Unit. Obtain the standard from the CADD operator and include the following information:

- Project and TIP numbers in large numerals in left hand margin
- State, TIP and Federal Aid project numbers in the upper right hand corner
- ***STRUCTURE(S)*** or ***CULVERT(S)*** on the left side of the plan sheet
- County name in large letters
- Description of project location
- Description of type of work (when applicable, include "bicycle lanes")
- Design designation
- Vicinity map
- Large scale map of project reflecting the beginning and ending stations of the structure
- Shipping point
- Length of the structure along the project
- North arrow
- Total number of sheets in the plans
- Letting date
- Name of Project Design Engineer and Project Engineer
- Title sheet should be signed and sealed by the State Bridge Design Engineer and signed by the State Highway Design Engineer.

12-3 Removing Existing Pavement In Order to Drive Piles

In cases where the Roadway Design Unit is to remove existing pavement so that end bent piles may be driven, the Roadway plans should state that:

> ***The existing pavement is to be removed and the roadbed scarified to a minimum depth of 2'-0"**(610 mm)* ***below original surface in the area where piles are to be driven through the proposed embankment, as directed by the Engineer.***

Place the following note on the General Drawing:

> ***The existing pavement within the area of the end bent piles shall be removed and the roadbed scarified to a minimum depth of 2'-0"**(610 mm)**.***

The above notes should be modified to exclude removing the existing pavement for gravel roads.

12-4 Adhesively Anchored Anchor Bolts or Dowels

For certain applications, the Contractor has the option of drilling holes in the concrete and filling them with an adhesive bonding material to install anchor bolts or dowels rather than using cast-in-place or preset anchors.

Most applications of adhesively anchored bolts/dowels will require field testing. For a list of these applications, as well as the level of testing required, see Figure 12-21. These anchor bolts/dowels will be tested to a load equal to either 50% or 80% of the yield load of the anchor bolt/dowel. Place the following note on the plans:

> ***The Contractor may use adhesively anchored*** *[anchor bolts/dowels]* ***in place of ______________. Level ___ field testing is required, and the yield load of the [anchor bolt/dowels] is____ kips. For Adhesively Anchored Anchor Bolts or Dowels, See Special Provisions.***

If no field testing is required, place the following note on the plans:

> ***The Contractor may use adhesively anchored*** *[anchor bolts/dowels]* ***in place of ______________. No field testing is required. For Adhesively Anchored Anchor Bolts or Dowels, See Special Provisions.***

The manufacturer will determine an embedment depth that ensures the adhesive bonding material develops at least 125% of the yield load of the anchor bolt or dowel. The Project Engineer, however, shall be responsible for noting any restrictions on, or special considerations of, the embedment depth of the anchor bolt/dowel such as a 2 inch (50 mm) minimum cover on thin concrete sections. If it is unclear whether there is adequate concrete thickness to develop a reasonable embedment depth, check the manufacturers' catalogs for typical embedment depths.

For bolts, the yield load shown on the plans should be based on the yield stress applied to the tensile stress area of the bolt. For rebar, the yield load is based on the yield stress applied to the cross section area of the bar.
There are a number of approved manufacturers of adhesive bonding systems; refer to the Materials and Tests Unit's approved products list and the respective manufacturer's websites.

No overhead applications of adhesively anchored anchor bolts or dowels will be allowed.

The Special Provision for Adhesively Anchored Anchor Bolts or Dowels states that there is no special payment for this system but that it shall be included in the unit contract price for the several pay items.

12-5 Rip Rap

The type of rip rap to be used for a given structure will be set by the Hydraulics Unit. If the type required is not clear on the Hydraulic Design Report, consult the Hydraulics Unit.

Filter fabric shall typically be placed under the area covered by rip rap for all rip rapped slopes. If filter fabric is not required, it will be indicated on the Bridge Survey Report. Show the filter fabric on the appropriate standard drawing section views showing a straight line between the ground line and the rip rap, denoted as filter fabric. Show the quantity of filter fabric in square yards (square meters) on the plans.

The following three standard drawings are available and should be used in plan development:

- RR1 - "Rip Rap Details - Skew < 90° "
- RR2 - "Rip Rap Details - Skew = 90° "
- RR3 - "Rip Rap Details - Skew > 90° "

The Standards are drawn to show general details. Some modification may be needed to suit a particular structure.

The usual slope condition at stream crossing sites is a 1½:1 front slope and 1½:1 or flatter side slopes with the transition, if necessary, in the cone. The general intention is not to place rip rap on a slope flatter than 2:1 slope; therefore, the roadway approach slopes flatter than 2:1 should be transitioned to 2:1 before the rip rap limits are reached. Rip rap shall be provided on slopes flatter than 2:1 on both the front and side slopes in some unusual cases, such as bridges over lakes.

In all cases where rip rap is specified, include the rip rap in tons (metric tons), in the structure contract. To convert square yards (square meters) to tons (metric tons), multiply by 0.90 for a 2 foot (0.98 for a 600 mm) layer of rip rap. See Figure 12-22.

12-6 Slope Protection

Slope protection shall be used beneath all grade separations. Unless otherwise specified by the Railroad, slope protection shall be used for railroad overheads. An aid for calculating concrete slope protection quantity is provided as Figure 12-23. When slope protection and a crashwall are detailed on the plans, provide a concrete swale behind the crashwall as detailed in Figure 12-24.

In general, dual bridges with median widths of 46 feet (14 m) or less shall receive continuous slope protection between the bridges.

See Standards SP1 and SP2 for slope protection details. When using the standard drawings, delete the options and details that are not allowed. Alternate "B" for stone slope protection shall be considered for grade separations with 2:1 end bent slopes in rural, unpopulated areas only. Filter fabric shall typically be placed under stone slope protection. Show the quantity of filter fabric in square yards (square meters) on the plans.

The toe of slope protection elevations should be shown on the Slope Protection Details Sheet. The elevations and corresponding offsets from the survey line under the bridge shall be shown at the permissible construction joint on the slope protection (see Roadway Standard 610.03) at a minimum of two locations as illustrated in Figure 12-25. This data will aid the contractor in locating the toe of the slope protection prior to construction of roadway ditches under the bridge.

12-7 Plans for Falsework and Forms

When preparing plans including cast-in-place deck slabs, hammerhead bents, arch culverts, box culverts with a top slab thickness of 18 inches (455 mm) or greater, or other special structures, place the following note on the plans:

> ***Detailed drawings for falsework and forms for this ________ shall be submitted. See Sheet SN*** *(Sheet SNSM)***.**

12-8 Temporary Structures

On all temporary structures, place an asphalt wearing surface for traction. This surface could be the same as that used on the detour approaches.

When there is roadway work on the project, the alignment for the temporary structures should be coordinated with the Roadway Design Unit. For projects without roadway work, the alignment shall be shown on the plans, preferably in the Location Sketch.

For grade separations, the specified length of the temporary bridge should be the same length as the permanent bridge.

12-9 Providing Access Facilities on New Bridges

For bridges where portions of the structure are inaccessible from the bridge deck or below, maintenance and inspection access details shall be included in the plans. These details may include walkways, platforms, or ladders.

The following criteria shall be used as a guide in determining which bridges require access facilities:

- Structures on which mechanical or electrical devices that require periodic maintenance or replacement are installed.
- Bridges with a vertical underclearance of 35 feet (10.7 m) or greater and an out-to-out deck width equal to or greater than that shown in Figure 12-26.
- Bridges over water or marshland that have an out-to-out deck width equal to or greater than that shown in Figure 12-26.
- For bridges with sidewalks that may require access facilities, the width of each sidewalk should be subtracted from the values shown in Figure 12-26 to determine the permissible out-to-out deck width.
- For bridges not meeting the criteria shown in Figure 12-26, the Bridge Maintenance Unit should be contacted for their recommendations.
- Out-to-out deck widths shown in Figure 12-26 shall be reduced for skewed bridges.

The final decision as to the need and type of access facility should be made in consultation with the Bridge Maintenance Unit. All access facilities shall meet OSHA requirements for structural size and safety criteria.

12-10 Shoring Adjacent to Existing Bridges

When constructing a new or temporary bridge adjacent to an existing bridge, consideration must be given to the need for temporary shoring.

For grade separations, the Structure Design Project Engineer will coordinate with the Roadway Design Unit and the Geotechnical Engineering Unit to determine the shoring requirements. If shoring is required, Structure Design will provide Roadway Design with a detail of the end bent slopes of the new bridge with the existing slope shown in dashed lines. For the note to be placed on the General Drawing, see Section 5-2 "Excavation and Shoring".

For stream crossings, the Structure Design Project Engineer will coordinate with the Geotechnical Engineering Unit to determine the shoring requirements. If shoring is required and there is a pay item for "Temporary Shoring" in the Roadway plans, the shoring quantity will be included in the Roadway plans. If there is not a Roadway pay item, include a square foot (square meter) pay item for "Temporary Shoring" on the Structure plans. For the note to be placed on the General Drawing, see Section 5-2 "Excavation and Shoring".

Temporary Shoring for the Maintenance of Traffic shall be detailed when needed to provide lateral support to the side of an excavation or embankment parallel to an open travelway when a theoretical 2:1 or steeper slope from the bottom of the excavation or embankment intersects the existing ground line closer than five feet from the edge of pavement of an open travelway. Shoring required for foundation or culvert excavation is considered Temporary Shoring for the Maintenance of Traffic if it also satisfies the above requirement.

The need for Temporary Shoring for Maintenance of Traffic shall be determined through coordination with Soils and Foundation, Traffic Control, and Roadway Design. This shoring will be shown on the Traffic Control Plans and the pay quantity provided in the roadway plans. When this shoring is required, indicate the shoring in the plan view of the general drawing and label it as "Temporary Shoring for the Maintenance of Traffic. See Notes." The beginning and ending stations for this shoring are not required on the plans. See Section 5-2 "Excavation and Shoring" for the note to be placed on the General Drawing.

Confer with Soils and Foundation to determine the limits and pay quantity of this shoring. The quantity of temporary shoring to be paid for will be the actual number of square feet (square meters) of exposed face of the shoring measured from the bottom of the excavation or embankment to the top of the shoring, with the upper limit not to exceed 1 foot (300 mm) above the retained ground line.

12-11 Foundation Excavation on Railroad Right of Way

General

Details for foundation excavation on railroad right of way shall be shown in the contract plans. Excavations may be detailed as either sloped open cuts or with temporary shoring.

When several substructure units are on the Railroad right of way, the Railroad may only require excavation details for the units closest to the track. In this situation, the Assistant State Bride Design Engineer will assist in obtaining permission from the Railroad to exclude the unnecessary excavation details from the plans.

To eliminate the need for foundation excavation for railroad crashwalls, bents shall be located to provide 25 feet (7.62 m) horizontal clearance from the centerline track whenever practical.

Shoring or Open Excavation Plans

When circumstances allow an open cut excavation, provide plan and section view details to show the limits of the excavation. The Geotechnical Engineering Unit must be consulted to determine the maximum permissible cut slope for the soil conditions. The plans should include the minimum distance from the centerline of the track to the top of the nearest excavation cut slope.

When temporary shoring is required, the design and plans shall be prepared in accordance with the requirements illustrated in Figure 12-27. The plans shall contain details of the shoring system including the size of all structural members, connection details, embedment depth and the distance from the centerline of track to the near face of shoring. The plans shall also include a section showing the height of the sheeting and the track elevation in relation to the bottom of the excavation (additional survey data may be needed in order to show this information). The inside face of the shoring shall be a minimum of 1'-6" (450 mm) outside the edge of the footing. Where it is not possible to design a shoring system without struts extending through the crashwall, place the details of Figure 12-28 on the plans.

Unless prior approval is received from the Railroad, all excavations on Railroad right of way shall be detailed with handrails. In addition, open excavations adjacent to tracks that are located within what is termed “normal walkways” by the Railroad shall be detailed with a walkway and handrails. Handrails shall not be located closer than 10 feet (3 m) horizontally from the centerline of the track.

Design Allowable stresses for concrete and steel shall be in accordance with the AREMA Specifications. Railroad surcharge loads shall be computed using the equation for a continuous strip of surcharge load from the AREMA Specification and shall be based on a Cooper's E80 live load model. The Geotechnical Engineering Unit is to be consulted in determining soil pressures, possible pile or sheeting penetrations, and slope stability of the highway approach fills and the open foundation excavations.

Coordination with the Geotechnical Engineering Unit may also be required to ensure that the Foundation Recommendations do not detail the footing at an elevation that interferes with the railroad ditch.

Plans prepared for shoring or open cut foundation excavation shall provide for the possibility of spread footings being lowered up to 3 feet (1 m).

Pay Items When the foundation excavation at a bent involves shoring that fully or partially encloses the excavation, each affected substructure unit will require two lump sum pay items as follows:

- "Shoring For Bent _____ "
- "Foundation Excavation For Bent _____ "

When the foundation excavation at a bent involves only an open cut, each affected substructure unit will require one lump sum pay item as follows:

- "Foundation Excavation For Bent _____ "

For a bridge that spans both a railroad and a highway or a stream, some of the substructure units may fall outside the Railroad right of way. Pay items and payment for "Foundation Excavation" for these units will be handled as outlined in Section 7-6 of this manual.

For the note to be placed on the General Drawing when Railroad approval has not been received prior to the letting, see Section 5-2 "Excavation and Shoring".

12-12 Corrosion Protection

General Corrosion protection is achieved through the use of one or more of the following measures: Increased clear cover for reinforcing steel, epoxy coating reinforcing steel, adding calcium nitrite corrosion inhibitor, silica fume, fly ash or granulated blast furnace slag, specifying Class AA concrete for substructures, and limiting the use of uncoated structural steel.

Corrosion protection is used to varying degrees for bridges on or east of the Corrosive (blue) Line of Figure 12-29 and in Divisions where significant road salt is applied. Figure 12-30 provides a flowchart to determine the extent of corrosion protection necessary for any bridge.

In Divisions 5, 7, or 9-14, corrosion protection focuses on the bridge deck, where mineral admixtures are added to the concrete to reduce permeability.

For Corrosive Sites, the corrosion protection is more comprehensive. Corrosive Sites are limited to stream crossings on or east of the Corrosive (blue) Line as defined by Figure 12-29. For these bridges, mineral admixtures may be required in all or some of the bridge members. Additionally, calcium nitrite is specified to increase corrosion resistance of the reinforcing steel. See Figure 12-30 for instructions on applying the various protection systems to each location.

For bridges located east of the Highly Corrosive (red) Line, all concrete will receive at least one corrosion protection measure. For bridges located between the Highly Corrosive (red) and Corrosive (blue) Lines of Figure 12-29, apply corrosion protection measures and notes to only those structural elements (i.e. prestressed concrete girder, cored slab, bent cap, column, etc,) that are located within 15 feet (4.5 m) of mean high tide. When any structural element is within 15 feet (4.5 m) of mean high tide, all similar elements in the bridge shall receive the same corrosion protection.

Corrosion Protection Measures

Corrosion protection measures are determined through the use of the flowchart of Figure 12-30 and the map of Figure 12-29. The notes below shall be used as directed by Figure 12-30.

Note #1: ***The class AA concrete in the bridge deck shall contain fly ash or ground granulated blast furnace slag at the substitution rate specified in Article 1024-1 and in accordance with Articles 1024-5 and 1024-6 of the Standard Specifications. No payment will be made for this substitution as it is considered incidental to the cost of the Reinforced Concrete Deck Slab.***

Note #2: ***All metallized surfaces shall receive a seal coating as specified in the Special Provision for Thermal Sprayed Coatings (Metallization).***Note #3: ***Class AA concrete shall be used in all cast-in-place columns, bent caps, pile caps, and footings, and shall contain calcium nitrite corrosion inhibitor. For Calcium Nitrite Corrosion Inhibitor, see Special Provisions.***

Note #: ***Prestressed concrete girders are designed for 0 psi*** *(0 MPa)* ***tension in the precompressed tensile zone under all loading conditions.***

Note #5: ***Precast panels shall be designed for an allowable tensile stress of 0 psi*** *(0 MPa)* ***in the precompressed tensile zone under all loading conditions.***

Note #6: ***The water/cement ratio for concrete piles shall not exceed 0.40.***

Note #7: ***All bar supports used in the*** *(barrier rail, parapet, sidewalk, deck, bent caps, columns, pile caps, footings)* ***and all incidental reinforcing steel shall be epoxy coated in accordance with the Standard Specifications.***

Note #8: ***Prestressed concrete*** *(girders, precast deck panels, cored slab units, piles)* ***shall contain calcium nitrite corrosion inhibitor. See Special Provisions for Calcium Nitrite Corrosion Inhibitor.***

For those elements of the structure that may undergo repeated wetting and drying cycles due to tidal fluctuations, 5% of the portland cement shall be replaced with silica fume. For mass concrete elements subject to repeated wetting and drying cycles, use fly ash in lieu of silica fume. Place the note below on the General Drawing. If precast elements require silica fume, also place the note on the precast element sheet or standard drawing:

Note #9: ***The concrete in the*** *(columns, bent caps, pile caps, footings, and/or piles)* ***of Bent No. ____ shall contain silica fume. Silica Fume shall be substituted for 5% of the portland cement by weight. If the option of Article 1024-1 of the Standard Specifications to partially substitute Class F fly ash for portland cement is exercised, then the rate of flay ash substitution shall be reduced to 1.0 lb*** *(1.0 kg)* ***of fly ash per 1.0 lb*** *(1.0 kg)****. No payment will be made for this substitution as it is considered incidental to the various pay items.***

In general, metal stay-in-place forms shall not be permitted. In special situations, such as in those channel spans of high level bridges where the use of prestressed concrete deck panels is not feasible, removable forms shall be required.

12-13 Weathering Steel and Steel Coatings

Weathering steel (AASHTO M270 Gr. 50W or Gr. 70W) shall not be used in "low-level" water crossings nor "tunnel-like" grade separations. Stream crossings that are less than 10 ft (3 m) above the normal water surface shall be considered "low-level". Grade separations where a depressed roadway is bounded by abutments or retaining walls, typically found in urban areas, shall be considered "tunnel-like".

Concrete or fully-painted steel(i.e., AASHTO M270 Gr. 36, 50 or 70) shall be used in lieu of weathering steel for superstructures of stream crossings, grade separations and railroad overheads in the following counties:

Brunswick	Hyde
New Hanover	Dare
Pender (on or East of NC 53)	Tyrrell
Onslow	Washington
Carteret	Chowan
Craven (on or east of US 17)	Perquimans
Jones (on or east of US 17)	Pasquotank
Pamlico	Camden
Beaufort	Currituck

Thermal Sprayed Coatings

When thermal sprayed coatings are required, place the applicable note(s) on the plans stating the type of alloy required and its required thickness. For most applications the alloy and thickness will be prescribed in the Special Provision. However, for some applications the alloy and thickness are required as outlined below.

Steel Piles in Corrosive Environments

For steel piles in a corrosive environment, 99.5 percent Aluminum (W-Al-1350) and a seal coat is required. Place the following note on the plans:

> ***Apply an 8 mil thick 1350 Aluminum (W-Al-1350) thermal spray coating with a 0.5 mil thick seal coat to the piles, in accordance with the Thermal Sprayed Coatings Special Provision and Section 442 of the Standard Specifications. For Thermal Sprayed Coatings, see Special Provisions.***

System 1 Paint is required on the portion of the steel pile (H or pipe piles) that is embedded in concrete. Place the following note on the plans:

> ***After driving the piles, apply 1 coat each of 1080-12 Brown and 1080-12 Gray paint to the embedded section of the metallized pile prior to concrete embedment in accordance with Section 442 of the Standard Specifications.***

In corrosive sites, exposed steel piles shall be used for fender systems only, shall contain 0.2% copper , be metallized and have a seal coat. Place the following note on the detail sheet:

> ***Steel piles for fender systems shall contain 0.2% copper, be metallized and have a seal cost. For Thermal Sprayed Coatings, see Special Provisions.***

Steel Girders

When thermal sprayed coatings are used on girders an approved seal coat is required. Place the following note on the plans:

> ***Apply an 8 mil thick 99.99 percent Zinc (W-Zn-1) thermal spray coating with a 0.5 mil thick seal coat to all girder surfaces in accordance with the Thermal Sprayed Coatings Special Provision and Section 442 of the Standard Specifications. Prior to application, create a companion coupon for approval by the Engineer. For Thermal Sprayed Coatings, see Special Provisions.***

Aesthetic Considerations

For applications where aesthetics are a major concern, add the following note to the plans:

> ***Prior to beginning metallization, the Contractor will provide metallized samples to the Engineer for approval.***

12-13 Retaining Walls

Reinforced Concrete Retaining Walls

Use a minimum footing depth of 12 in (300 mm) for all retaining walls. For other design criteria, see Section 2-6 "Earth Pressures".

Provide vertical contraction joints in the wall at approximately 30 ft (9 m) centers and expansion joints at approximately 90 ft (27 m) centers. Dovetail the expansion joints and use 1 in (25 mm) expansion joint material up to within 12 in (300 mm) of the top of the wall. Provide a 6 in (152 mm) ϕ plastic waterstop to extend from the construction joint in the footing to 6 in (150 mm) below the top of the wall. Plastic waterstops are not required in retaining walls adjacent to a stream.

Consider special construction requirements, such as temporary sheeting that may require Special Provisions or notations on the plans.

Proprietary Retaining Wall and Abutment Structures

Proprietary retaining wall and abutment structures (i.e., Reinforced Earth, Retained Earth, or Hilfiker Wall) are included in the Structure plans. In the case where there are no bridges or culverts on the project, the proprietary retaining wall and abutment structure will be the only structure in the Structure plans.

Provide a sheet in the plans showing the plan and elevations of the proposed retaining walls.

After the letting, the Geotechnical Engineering Unit receives proprietary wall plans from the wall manufacturer. The Geotechnical Engineering Unit will check the wall for bearing capacity, sliding, overturning and other items pertaining to soil mechanics. The Structure Design Project Engineer will receive this package from the Geotechnical Engineering Unit to check the structural elements of the wall.

Place the following note on the plans:

For MSE Retaining Walls, see Special Provisions.

Show a sketch on the plans indicating the structure excavation limits for the installation of the walls. See Figures 12-31 and 12-32 for examples of appropriate sketches for various types of walls.

12-14 Closed Structure Drainage System

When required by the Hydraulics Unit, a closed structure drainage system shall be detailed on the plans. Payment for the drainage system shall be shown on the Total Bill of Material at the lump sum price for "Structure Drainage System". For structure drainage system details, see Figures 12-33, 12-34 and 12-35.

Place the following notes on the plans:

For Structure Drainage System, see Special Provisions.

The Contractor shall submit a plan for the drainage system, including, but not limited to, attachments to the bridge, scupper and inlet grate details, scupper support system, pipe alignment and pipe lengths, and all necessary fittings, elbows, wyes, adapters, guides and joints.

Shear studs or stirrups may be cut as approved by the Engineer to avoid interference with the bridge scupper.

Locate scuppers in the Plan of Spans as directed by the Hydraulics Unit. Provide reinforcement around the scupper as detailed on Standard BS2, "Bridge Scupper Details." Size inlet grates based on overhang and flange widths and recommendations from the Hydraulics Unit. Locate corresponding downspouts on an elevation view of the drainage system. Provide a general schematic drawing of the system but do not detail pipe lengths, fittings, elbows, or other such details. See Figure 12-33.

Detail a longitudinal drain pipe with a minimum slope of 0.5% or as otherwise directed by the Hydraulics Unit. Typically, this drain pipe will be located immediately inside an exterior girder. Provide expansion joints in the drain pipes at a maximum spacing of 25 feet (7.5 m). Detail the location of pipe hangers and concrete inserts at a maximum spacing of 6 feet (2 m). Reduce this spacing to a maximum of 5 feet (1.5 m) surrounding each downspout and pipe expansion joint. A detail of the concrete insert placement is provided in Figure 12-34. Detail a cleanout at each end of each longitudinal drain pipe and along the column downspout as detailed in Figure 12-33.

Include section views on the plans that show the position of the drain pipe relative to the diaphragms as shown in Figure 12-35. The cleanouts over the bent should be aligned to avoid interference with the bent diaphragm.

If a junction box is required to accept the drainage from the system, coordinate with the Roadway Design Unit to locate the junction box. Place the following note on the plans:

See Roadway Plans for details and pay item for junction box at approximate Station _______.

12-15 Sound Barrier Walls

Pile panel sound barrier walls shall be in accordance with Standards SBW1 and SBW2 and the Special Provisions. The wall components shall be designed for the wind pressure as determined by the Exposure Category map of Figure 12-36. Options and details shall be provided on the standard drawings to allow the use of either a 10 foot (3.1 m), or 15 foot (4.6 m) panel.

The appropriate pile selection table from Standard SBW1 should be placed on the plans. The dead load, ice load, and wind loads have been considered in the panel and pile design. For walls subject to any additional loadings, the pile and panel shall be designed on a case by case basis. In addition, walls exceeding 29 feet (8.840 m) in height shall be designed on a case by case basis.

The Geotechnical Engineering Unit will determine the drilled pier lengths to be shown on Standard SBW1. Calculate the soil loads based on Figure 12-37, excluding the weight of the pile and drilled pier. Submit the loads and a copy of the Roadway Plan sheet that locates the wall to the Soils and Foundation Unit.

The required horizontal reinforcement in the precast panels, as determined by Figure 12-37, should be detailed on Standard SBW2 and the quantity tables for one precast panel shall be completed. The number and size of panels does not need to be computed; however, the estimated area, as computed from the Roadway plans, of the wall should be reported on Standard SBW2.

The completed standard drawings for the wall shall be transmitted to the Roadway Design Unit for inclusion with the wall layout and envelope in the Roadway plans.

12-16 Electrical Conduit System

The design of the Electrical Conduit System is categorized by its attachment to the superstructure. The three options are attachment to SIP forms, precast deck panels, or overhangs. Use the overhang option only when designing a stream crossing or a railroad crossing.

Every structure designed with an electrical conduit system shall use a conduit Expansion Joint Fitting and a Transition Adapter at each end bent and an

Expansion Joint Fitting at each expansion joint in the deck. A Stabilizer should also be detailed midway between deck expansion joints. A Deflection Coupling is to be used only on structures on a horizontal curve that require the conduit to bend laterally to complete the installation. When a Deflection Coupling is required, place the following note on ECS1 or ECS1SM:

> ***Install Deflection Coupler at each bent. See Detail "F".***

When the Electrical Conduit System is used on bridges designed for precast deck panels, place the following note on the Precast Panel Standard PDP1:

> ***¾" (19 mm) diameter pipe sleeve inserts shall be installed at a maximum of 10 foot (3m) centers to accommodate the Electrical Conduit System. See Electrical Conduit Systems Details.***

Payment for the Electrical Conduit System will be as "Lump Sum". No bill of material for the Conduit System will be required.